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—(Recognosce notum, ignotum inspice)

TRANSACTIONS

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Edited by

J. RAMSBOTTOM, B. F. BARNES and H. WORMALD

THE STROUD FORAY

May 11th–15th, 1934

By E. M. WAKEFIELD

THE Spring Foray for 1934 was held during the week-end May 11th–
15th, with headquarters at the Amberley Ridge Hotel, near Stroud.
  The first day's excursion was to Cranham Woods, between Pains-
wick and Cheltenham. A start was made from the hotel at 10.15 a.m.,
and the party travelled by bus as far as the King William Hotel, near
Cranham Corner. Some little time was spent in the woods behind the
hotel in a search for *Pyrola*, which had been found there during the
Painswick Foray in 1920, attacked by its rust, *Chrysomyxa Pyrolae*.
Unfortunately, however, the plant appears to have now become
almost extinct in that locality, owing to the use of the wood by picnic
parties.
  A move was then made towards Cranham Corner, and the woods
between there and Cranham Village were explored. Owing to the
dry winter and spring the larger fungi were very scarce. The most
noteworthy find was *Sarcosphaera coronaria*, which occurred in abund-
ance in certain spots, growing amongst moss on the ground and at the
foot of banks beside the paths. A few rusts and other microfungi were
secured, but nothing of any special interest.
  On the following day, Sunday, Woodchester Park was the ob-
jective. Sufficient private cars were available, and by a steep and
narrow rutty lane the party arrived in procession at the gates of the
Park, and were admitted by the lodge-keeper. The Park was found
to be a place to rejoice a botanist's heart, and many remarked how
good it would be for fungi in autumn. At this time, like the rest of the
country, it had suffered from the drought, but at the same time the
variety of vegetation provided many more fungi than had been found
on the previous day. Some cherries were found badly attacked by
leaf-curl (*Taphrina minor*). Among other microfungi collected were
Entyloma Ranunculi, abundant on *Ranunculus Ficaria*, and *Endophyllum
Euphorbiae-sylvaticae* on *Euphorbia amygdaloides*. Basidiomycetes were
also more in evidence, owing partly to moisture provided near a chain
of lakes, and partly to the presence of plenty of rotting wood.
Eichleriella spinulosa, found during the Painswick Foray, was again
collected, while of the larger fungi *Tricholoma gambosum*, *Coprinus
ephemerus*, and *Polyporus dryadeus* may be noted.
  Monday was devoted to the exploration of Cirencester Park. Here
again, however, fungi were very few. A good group of *Morchella
rotunda* was found, fine large specimens, some of which were taken

for a culinary test. There was little of any special interest, but *Penio-phora longispora* and *Aleuria umbrina* were among the less common species recorded.

During the week-end a meeting was held to consider proposals for the 1935 Spring Foray. After considerable discussion Derbyshire (Buxton or Matlock) was proposed, and Tunbridge Wells was suggested as an alternative should it not be possible to arrange for a Derbyshire meeting. The final decision was left with the Council.

Miss L. Hunter, of Toronto, gave an informal account of her work on the genus *Milesia*. Mr Petch gave an interesting talk on some entomogenous fungi found in caves, and Dr Alex. Smith showed specimens of the very rare *Puccinia Bulbocastani* on *Carum Bulbocastanum*. At the close of the meeting votes of thanks were accorded, and special thanks were expressed to Mr E. M. Day, who had made all arrangements for the very pleasant meeting. Members regretted that owing to illness Mr Day was unable to join in the excursions.

The Secretary is indebted especially to Mr Ramsbottom, Mr Pearson, Dr Alex. Smith, Mr T. Petch, and Mr E. W. Mason for assistance in compiling the subjoined list.

Complete List of Species found during the Foray

P. = Cranham Woods, near Painswick; *C.* = Cirencester Park; *W.* = Woodchester Park; *A.* = Amberley Hotel grounds.

HYMENOMYCETES

Armillaria mellea (Vahl) Fr., rhizomorphs, *C.*
Tricholoma gambosum Fr., *W.*
Mycena amicta Fr., *P.*
Marasmius globularis Fr., *C.*, dryophilus (Bull.) Karst., *C.*
Panus stipticus (Bull.) Fr., *W.*
Schizophyllum commune Fr., *W.*
Nolanea pascua (Pers.) Fr., *W.*
Pholiota praecox (Pers.) Fr., *W.*, *C.*, mutabilis (Schaeff.) Fr., *W.*
Hebeloma crustuliniforme (Bull.) Fr., *C.*
Galera tenera (Schaeff.) Fr., *C.*, *P.*
Naucoria melinoides Fr., *W.*
Tubaria furfuracea (Pers.) W. G. Sm., *P.*
Crepidotus mollis (Schaeff.) Fr., *W.*
Psalliota campestris (Linn.) Fr., *C.*
Hypholoma fasciculare (Huds.) Fr., *P.*, *W.*, *C.*, velutinum (Pers.) Fr., *P.*, appendi-
    culatum (Bull.) Fr., *P.*, *W.*
Psilocybe foenisecii (Pers.) Fr., *W.*
Psathyrella disseminata (Pers.) Fr., *P.*
Panaeolus campanulatus (Linn.) Fr., *W.*
Coprinus micaceus (Bull.) Fr., *C.*, *P.*, velox Godey, *C.*, ephemerus (Bull.) Fr.,
    P., plicatilis (Curt.) Fr., *P.*, *W.*
Polyporus squamosus (Huds.) Fr., *W.*, *C.*, sulphureus (Bull.) Fr., *C.*, dryadeus
    (Pers.) Fr., *W.*, radiatus (Sow.) Fr., *W.*, fumosus (Pers.) Fr., *P.*, adustus
    (Willd.) Fr., *W.*, *C.*, caesius (Schrad.) Fr., *W.*, *P.*
Fomes ulmarius (Sow.) Fr., *W.*, *C.*, ferruginosus (Schrad.) Mass., *W.*

Ganoderma applanatum (Fr.) Pat., *W.*
Polystictus versicolor (Linn.) Fr., *P., W., C.*, abietinus (Dicks.) Fr., *W.*
Irpex obliquus (Schrad.) Fr., *W.*
Lenzites betulina (Linn.) Fr., *W.*
Trametes gibbosa (Pers.) Fr., *W.*, mollis (Sommerf.) Fr., *W.*
Daedalea quercina (Linn.) Fr., *W.*
Stereum spadiceum Fr., *W.*, rugosum (Pers.) Fr., *W.*, hirsutum (Willd.) Fr., *W.*,
    purpureum Pers., *W., C.*
Corticium laeve Pers., *W., C.*, lividum (Pers.) Fr., *C.*, porosum B. & C., *C.*,
    praetermissum (Karst.) Bres., *W.*, lactescens Berk., *W.*
Peniophora longispora (Pat.) v. H. & L., *C.*, cremea Bres., *W., C.*, velutina (DC.)
    Cooke, *W.*, hydnoides Cooke & Mass., *W., C.*, cinerea (Fr.) Cooke, *W., C.*
Auricularia auricula-Judae (Linn.) Schroet., *W.*
Tremella mesenterica (Retz.) Fr., *W.*
Exidea nucleata (Schw.) Rea, *P.*, Thuretiana (Lév.) Fr., *C.*
Eichleriella spinulosa (B. & C.) Burt., *W.*

GASTEROMYCETES

Lycoperdon perlatum Pers., *C.*

UREDINALES

Uromyces Ficariae (Schum.) Lév., *W.*, Acetosae Schroet., *W.*, Alchemillae (Pers.)
    Lév., *C.*, Scillarum (Grev.) Wint., *P., C.*, Dactylidis Otth, aecidium on
    Ranunculus, *P.*
Puccinia Anemones Pers., *P., C.*, Violae (Schum.) DC., *P.*, pulverulenta Grev., *W.*,
    Saniculae Grev., *P.*, Celakovskiana Bubák, *W.*, obtegens (Link) Tul., *W.*,
    Hieracii (Schum.) Mart., *P.*, Taraxaci Plowr., *P.*, Buxi DC., *C.*
Kuehneola albida (Kuehn.) Magn., *W., C.*
Ochropsora Sorbi (Oud.) Diet., aecidium on *Anemone*, *P.*
Endophyllum Euphorbiae-sylvaticae Wint., on *Euphorbia amygdaloides*, *P., W.*

USTILAGINALES

Entyloma Ranunculi (Bon.) Schroet., on *Ranunculus Ficaria*, *W.*
Urocystis Anemones (Pers.) Schroet., *P., C.*

PYRENOMYCETES

Podosphaera Oxyacanthae (DC.) de Bary, *P.*
Sphaerotheca pannosa (Wallr.) Lév., *P.*
Microsphaera Berberidis (DC.) Lév., on *Mahonia Aquifolium*, *A.*
Erysiphe graminis DC., *W.*
Nectria Peziza (Tode) Fr., *C.*, sanguinea (Bolt.) Fr., *W.*
Hypomyces rosellus (A. & S.) Tul., *W.*, aurantius (Pers.) Tul., *C.*
Leptospora ovina (Pers.) Fuck., *W.*
Stigmatea Robertiana Fr., *P.*
Eutypa Acharii Tul., on *Acer*, *W.*, lata (Pers.) Tul., *C.*, spinosa (Pers.) Tul., *C.*
Botryosphaeria Dothidea (Moug.) Ces. & de Not., on *Rosa arvensis*, *P.*
Diatrypella quercina (Pers.) Nits., *W.*
Diatrype Stigma (Hoffm.) Fr., on *Fagus*, *W.*
Ustulina vulgaris Tul., *P., W., C.*
Hypoxylon coccineum Bull., *W.*, fuscum (Pers.) Fr., on *Corylus*, *W., C.*
Daldinia concentrica (Bolt.) Ces. & de Not., *W.*
Xylaria Hypoxylon (Linn.) Grev., *C.*

HYSTERIALES

Dichaena faginea Fr., *C.*

DISCOMYCETES

Morchella rotunda (Pers.) Boud., *C.*
Aleuria umbrina Boud., *C.*
Sarcosphaera coronaria (Jacq.) Boud., *P.*
Cheilymenia coprinaria (Cooke) Boud., *P.*
Ascobolus stercorarius (Bull.) Schroet., *P.*
Dasyobolus immersus (Pers.) Sacc., *P.*
Pyronema omphalodes (Bull.) Fuck., *C.*
Taphrina minor Sadeb., on *Cerasus, W.*
Calycella citrina (Hedw.) Quél., *W.*
Bulgaria inquinans (Pers.) Fr., *C.*
Dasyscypha virginea (Pers.) Fr., *P.*
Rhytisma acerinum (Pers.) Fr., *P.*

PHYCOMYCETES

Cystopus candidus (Pers.) de Bary, on *Arabis, A.*
Plasmopara pygmaea Schroet., on *Anemone, W., C.*
Peronospora alsinearum Casp., *W.*, calotheca de Bary, *C.*
Empusa Muscae Cohn, *A.*

DEUTEROMYCETES

Stagonospora Curtisii (Berk.) Sacc., *A.*
Septoria Rubi West., *P.*
Ceuthospora phacidioides Grev., on *Ilex, C.*
Gloeosporium Helicis (Desm.) Oud., *P.*
Leptostroma filicinum Fr., *W.*
Gliocladium penicillioides Corda, on *Didymium squamulosum, W.*
Botrytis cinerea Pers., *W.*
Cylindrodendrum album Bon., on Alder catkins, *W.*
Ovularia obliqua (Cooke) Oud., *W.*
Beauveria Bassiana (Bals.) Vuill., on weevils, *P.*
Ramularia acris Lindr., on *Ranunculus repens, W.*, Calthae Lindr., *W.*
Bispora monilioides Corda, *P., C.*
Tilachlidium tomentosum (Schrad.) Lindau, on *Trichia varia, C.*
Isaria farinosa (Holmsk.) Fr., on pupae, *P.*

MYCETOZOA

By T. Petch

Ceratiomyxa fruticulosa Macbr., *W.*
Physarum nutans Pers., *C.*, viride Pers., *C.*
Fuligo septica Gmel., *W.*
Didymium squamulosum Fr., *W.*
Stemonitis fusca Roth, *W.*
Comatricha typhoides Rost., *W., C.*
Lycogala epidendrum Fr., *P., W., C.*
Trichia affinis de Bary, *C.*, persimilis Karst., *C.*, varia Pers., *C.*, decipiens Macbr., *W., C.*
Arcyria denudata Wettst., *P., W., C.*, incarnata Pers., *W.*

THE NORWICH FORAY

October 1st–6th, 1934

By E. M. WAKEFIELD

THE thirty-eighth Autumn Foray and Annual General Meeting was held at Norwich during the week October 1st–6th, at the invitation of the Norfolk and Norwich Naturalists' Society. By kind permission of the Castle Museum Committee, headquarters were at the Castle Museum, where a room for meetings was available, and space for the exhibition of specimens. Here a large number of members and visitors assembled on the Monday evening, and were met by members of the Norfolk and Norwich Naturalists' Society. Miss Geldart, Vice-President of the Norfolk and Norwich Naturalists, made a short speech of welcome, to which Mr Ramsbottom replied on behalf of the British Mycological Society.

On the morning of October 2nd an early start was made by special coach in the direction of Cromer. Stopping at Northrepps Hall, the party were welcomed by Mrs and Miss Gurney, and after a glance through the gardens proceeded to work through Overstrand Woods, mixed woods with a considerable number of conifers (spruce and silver fir). *Hymenochaete Mougeotii* was soon discovered. It was first found in these woods some years ago. One of the most striking finds was a fallen trunk of silver fir which was completely covered with *Polyporus benzoinus*. Seen thus in a fresh and actively growing state the fungus is very different in appearance from the dark-coloured, shrivelled, dried specimens. In the growing state it has a conspicuous, swollen, white margin, immediately behind which there is a bright brown zone. Some of the firs in these woods were obviously failing, and as both *Armillaria mellea* and *Fomes annosus* were commonly present it is probable that these two fungi were doing considerable damage. After traversing these woods the party was picked up again by the coach, and taken on to woods at West Runton, where *Hymenochaete Mougeotii* was again turned up. Rain began soon after lunch and became very heavy towards tea time, so that after tea the party was glad to get into the coach and return to Norwich.

Wednesday's excursion was to Westwick and North Walsham, starting at 11.0 a.m. Westwick proved very rich in fungi, and most members felt they could have profitably spent the day in the area where they were first put down. The long subsequent walk to North Walsham yielded very little, but tea at the end, kindly provided by Mr and Mrs J. B. Brookes, was most welcome. A brief roadside survey before actually entering the woods at Westwick yielded

numerous Agarics and Boleti, including *Boletus viscidus*, *B. elegans*, *Paxillus atrotomentosus*, and other conifer-loving species. In the woods *Sparassis crispa* was found, and other noteworthy records were *Russula claroflava*, *R. sphagnophila*, *R. paludosa* Britz., and *Puccinia Hydrocotyles*. The woods at North Walsham yielded *Cordyceps capitata* and *C. ophioglossoides*.

Thursday was spent chiefly in woods and heathy ground at Stratton Strawless. Almost at once a quantity of the curious, sterile mycelium known as *Anthina flammea* was found amongst dead leaves. By the roadside *Pulvinula constellatio* was secured, and in the woods the most noteworthy finds were *Sparassis crispa*, *Cyathus striatus*, *Helvella lacunosa*, *Russula sphagnophila*, *Cortinarius phoeniceus*, *Volvaria bombycina*, *Leptonia sarcita*, and *Polyporus brumalis*. After tea at Cawston a short visit was paid to Buxton Heath, the only known locality for *Bovistella paludosa*. One old specimen was secured, but the visit was evidently too late for getting this fungus in good condition. On the Heath were found also *Entoloma Bloxamii*, and *Leptonia formosa*.

On Friday, October 5th, the party spent the morning in Sprowston and Plumstead Woods, and the afternoon at Framingham Chase and Framingham Manor Woods. At Framingham *Puccinia Antirrhini* was noticed in great quantity in a lodge garden, and at the same place was found a rather meagre specimen of *Cronartium asclepiadeum* Fr., on *Tropaeolum majus*. A small party made a special expedition to Wheatfen Broad, Surlingham, and added a number of records to the list.

The Annual General Meeting was held on the Tuesday evening, when the Officers and Council for the ensuing year were elected. Dr Malcolm Wilson was unanimously elected as President for 1935. Dr B. Barnes and Mr F. G. Gould are Vice-Presidents. The Treasurer, Secretaries and Editors remain as before. New members of Council, to replace those retiring under the Rules, are Mr C. G. C. Chesters, Mr H. J. Howard, and Mr H. H. Knight.

The list of members of the Plant Pathology Committee for 1935, elected by the Committee, was read and confirmed. New members are Mr Cartwright, Mr Ogilvie, and Miss K. Sampson.

A very warm invitation had been received from representative Irish botanists to hold the 1935 Autumn Foray at Killarney. It was felt, however, that southern England was due for a visit, and, moreover, the visit to Belfast had been comparatively recent. For this reason Dr O'Connor, who had transmitted the invitation, was asked if it might be held over for a future date. For 1935 it was decided to try to arrange a Foray in Devon.

The Presidential Address, on "Induced Variation", was delivered by Dr Barnes on Wednesday evening, October 3rd. On Thursday evening Mr H. Ramage (visitor) gave a talk on the Mineral Content of

Fungi, illustrated by lantern slides showing spectra. Miss Cayley gave a preliminary account of some work she had been doing with mushrooms, especially the species *Psalliota campestris, hortensis*, and *arvensis*.

On Friday evening Mr Rea contributed one of his informal and instructive talks on the more interesting species of fungi which had been found during the week.

The meeting ended with hearty votes of thanks to all the landowners concerned, to the Norfolk and Norwich Naturalists, and to the Committee and Staff of the Castle Museum, and particularly to Mr G. J. Cooke, who had made all the local arrangements and who with Mrs Cooke had contributed so much enthusiasm and energy to the organisation of a most enjoyable foray.

For assistance in compiling the attached list of species the Secretary is indebted to all members present, but especially to Mr Rea, Mr Ramsbottom, Mr Pearson, Mr Petch, Mr E. W. Mason, and Dr Alex. Smith.

Complete List of Species found during the Foray

N. = Northrepps Hall and Overstrand Woods; *R.* = West Runton; *W.* = Westwick and North Walsham; *S.* = Stratton Strawless; *B.* = Buxton Heath; *P.* = Sprowston and Plumstead Woods; *F.* = Framingham Chase; *C.* = Cawston; *G.* = Wheatfen Broad, Surlingham.

HYMENOMYCETES

Amanita verna (Lam.) Fr., *N., R., W.*, phalloides (Vaill.) Fr., *W., P., S.*, porphyria (A. & S.) Fr., *S.*, mappa (Batsch) Fr., *R., W., S., P.*, and var. alba (Gill.) Rea, *S.*, muscaria (Linn.) Fr., *R., W., S.*, and var. formosa Fr., *S.*, spissa Fr., *W., S.*, rubescens (Pers.) Fr., *N., R., W., S., P., G.*

Amanitopsis fulva (Schaeff.) W. G. Sm., *W., P., S., G.*

Lepiota procera (Scop.) Fr., *R., S.*, rhacodes (Vitt.) Fr., *S.*, echinella Quél. & Bern., *P., G.*, felina (Pers.) Fr., *N., R.*, cristata (A. & S.) Fr., *W., S.*, granulosa (Batsch) Fr., *N., W.*, amianthina (Scop.) Fr., *W.*

Armillaria mellea (Vahl) Fr., *N., W., P., S., G.*, mucida (Schrad.) Fr., on beech and oak, *S.*

Tricholoma resplendens Fr., *F.*, fulvum (DC.) Fr., *S.*, albobrunneum (Pers.) Fr., *W., S.*, rutilans (Schaeff.) Fr., *N., R., W., P.*, acerbum (Bull.) Fr., *W.*, nudum (Bull.) Fr., *N.*, cinerascens (Bull. non Fr.) Quél., *S., P.*, grammopodium (Bull.) Fr., *S.*, melaleucum (Pers.) Fr., *W., S.*, sordidum (Schum.) Fr., *W.*

Clitocybe nebularis (Batsch) Fr., *S.*, clavipes (Pers.) Fr., *W., S.*, aurantiaca (Wulf.) Studer, *N., R., W., F., G.*, and var. albida (Gill.) Rea, *W., B.*, odora (Bull.) Fr., *W.*, rivulosa (Pers.) Fr., *W.*, candicans (Pers.) Fr., *R.*, infundibuliformis (Schaeff.) Fr., *N., R., W., G.*, inversa (Scop.) Fr., *P.*, flaccida (Sow.) Fr., *W., G.*, suaveolens (Schum.) Fr., *N., W., F., P.*, ditopus Fr., *W.*, vibecina Fr., *N., S.*

Laccaria laccata (Scop.) B. & Br., *N., W., S., P., G.*, and var. amethystina (Vaill.) B. & Br., *N., S., F.*

Collybia radicata (Relh.) Berk., *W., S., F., P.*, platyphylla (Pers.) Fr., *R., N., W.*, maculata (A. & S.) Fr., *N., R., W., P., G.*, distorta Fr., *W.*, butyracea (Bull.) Fr., *W.*, cirrhata (Schum.) Fr., *N., S.*, tuberosa (Bull.) Fr., *R., W., S., F.*, atrata Fr., *S.*, protracta Fr., *N.*

Mycena pelianthina Fr., *N.*, rubro-marginata Fr., *R.*, *P.*, pura (Pers.) Fr., *N.*, *W.*, *S.*, *F.*, *G.*, lineata (Bull.) Fr., *S.*, galericulata (Scop.) Fr., *N.*, *R.*, *S.*, *P.*, *G.*, polygramma (Bull.) Fr., *S.*, alcalina Fr., *N.*, ammoniaca Fr., *N.*, *R.*, *W.*, vitilis Fr., *R.*, amicta Fr., *F.*, Iris Berk., *P.*, *F.*, sanguinolenta (A. & S.) Fr., *N.*, *R.*, *W.*, *S.*, *F.*, galopus (Pers.) Fr., *N.*, *W.*, *S.*, *P.*, and var. alba Fl. Dan., *R.*, and var. nigra Fl. Dan., *W.*, epipterygia (Scop.) Fr., *S.*, vulgaris (Pers.) Fr., *W.*, stylobates (Pers.) Fr., *N.*, *W.*, *F.*

Omphalia fibula (Bull.) Fr., *N.*, *W.*, *P.*, umbellifera (Linn.) Fr., *R.*

Pleurotus corticatus Fr., *W.*, acerosus Fr., *C.*, applicatus (Batsch) Quél., *S.*

Hygrophorus conicus (Scop.) Fr., *S.*, nigrescens Quél., *P.*, chlorophanus Fr., *S.*

Lactarius torminosus (Schaeff.) Fr., *W.*, *S.*, turpis (Weinm.) Fr., *W.*, *S.*, *G.*, *F.*, *P.*, blennius Fr., *W.*, *S.*, chrysorheus Fr., *W.*, vellereus Fr., *P.*, deliciosus (Linn.) Fr., *W.*, pallidus (Pers.) Fr., *R.*, *W.*, quietus Fr., *W.*, *S.*, *F.*, *P.*, *G.*, theiogalus (Fr.) Plowr., *W.*, *P.*, vietus Fr., *W.*, *S.*, rufus (Scop.) Fr., *R.*, *W.*, *F.*, *P.*, glyciosmus Fr., *R.*, *W.*, *S.*, serifluus (DC.) Fr., *N.*, *S.*, *P.*, mitissimus Fr., *S.*, subdulcis (Pers.) Fr., *W.*, *S.*, tabidus Fr., *W.*

Russula chloroides (Krombh.) Bres., *N.*, *W.*, nigricans (Bull.) Fr., *N.*, *R.*, *G.*, adusta (Pers.) Fr., *R.*, *W.*, *S.*, *P.*, *G.*, azurea Bres., *R.*, cyanoxantha (Schaeff.) Fr., *N.*, *R.*, *W.*, *S.*, *G.*, furcata (Pers.) Fr., *W.*, heterophylla Fr., *W.*, *S.*, *P.*, *G.*, pectinata (Bull.) Fr., *N.*, ochroleuca (Pers.) Fr., *N.*, *R.*, *W.*, *S.*, *P.*, *G.*, claroflava Grove, *W.*, fellea Fr., *N.*, *R.*, *W.*, *S.*, *P.*, drimeia Cooke, *W.*, *P.*, and var. Queletii (Fr.) Bat., *N.*, fragilis (Pers.) Fr., *W.*, *S.*, *P.*, emetica (Schaeff.) Fr., *R.*, *W.*, *S.*, atropurpurea (Krombh.) Maire, *N.*, *S.*, *P.*, *G.*, xerampelina (Schaeff.) Fr., *S.*, grisea (Pers.) Bres., *R.*, puellaris Fr., *W.*, vesca Fr., *W.*, *S.*, caerulea Cooke, *W.*, sphagnophila Kauffm., *S.*, *W.*, paludosa Britz., *W.*

Cantharellus cibarius Fr., *R.*, *W.*, *P.*, *S.*, infundibuliformis (Scop.) Fr., *W.*

Marasmius peronatus (Bolt.) Fr., *N.*, *W.*, *S.*, *G.*, oreades (Bolt.) Fr., *R.*, conigenus (Pers.) Karst., *R.*, *W.*, *G.*, erythropus (Pers.) Fr., *W.*, *S.*, *P.*, hariolorum (DC.) Quél., *N.*, *S.*, *P.*, dryophilus (Bull.) Karst., *N.*, *F.*

Androsaceus androsaceus (Linn.) Pat., *W.*, *S.*, epiphyllus (Fr.) Pat., *S.*

Panus torulosus (Pers.) Fr., *W.*, *S.*

Volvaria bombycina (Schaeff.) Fr., *S.*

Pluteus cervinus (Schaeff.) Fr., *N.*, *P.*, *S.*, salicinus (Pers.) Fr., *W.*, pellitus (Pers.) Fr., *P.*

Entoloma Bloxamii Berk., *B.*, sericeum (Bull.) Fr., *S.*, *B.*

Nolanea proletaria Fr., *S.*, cetrata (Fr.) Schroet., *R.*, *S.*

Leptonia formosa Fr., *B.*, sarcita (Fr.) Quél., *S.*

Clitopilus prunulus (Scop.) Fr., *W.*, *S.*, *P.*

Claudopus variabilis (Pers.) W. G. Sm., *S.*, *G.*

Paxillus involutus (Batsch) Fr., *N.*, *R.*, *F.*, *W.*, *S.*, *G.*, atrotomentosus (Batsch) Fr., *W.*, giganteus (Sow.) Fr., *F.*

Pholiota erebia Fr., *N.*, *W.*, togularis (Bull.) Fr., *N.*, *R.*, praecox (Pers.) Fr., *S.*, radicosa (Bull.) Fr., *G.*, squarrosa (Mull.) Fr., *P.*, spectabilis Fr., *N.*, *F.*, *P.*, flammans Fr., *N.*, marginata (Batsch) Fr., *W.*

Hebeloma sinuosum Fr., *S.*, fastibile Fr., *R.*, mesophaeum Fr., *R.*, *W.*, *S.*, *P.*, *F.*, crustuliniforme (Bull.) Fr., *S.*, *P.*

Inocybe pyriodora (Pers.) Fr., *S.*, tomentosa (Jungh.) Quél., *W.*, corydalina Quél., *W.*, geophylla (Sow.) Fr., *R.*, *W.*, *P.*, *G.*, and var. lilacina Fr., *W.*, descissa Fr., *S.*, obscura (Pers.) Fr., *S.*, lacera Fr., *W.*, *S.*, cincinnata Fr., *W.*, fastigiata (Schaeff.) Fr., *R.*, *W.*

Astrosporina umbrina (Bres.) Rea, *W.*, petiginosa (Fr.) Rea, *W.*

Galera tenera (Schaeff.) Fr., *W.*, *S.*, spartea Fr., *S.*, rubiginosa (Pers.) Fr., *B.*, hypnorum (Schrank) Fr., *N.*, *S.*, *F.*, *P.*

Naucoria semiorbicularis (Bull.) Fr., *S.*, Myosotis Fr., *W.*, sobria Fr., *N.*, escharoides Fr., *W.*, badia Kühner (=N. umbrina R. Maire), *W.*

Tubaria furfuracea (Pers.) W. G. Sm., *W.*, *S.*, crobulus Fr., *S.*

Flammula gummosa (Lasch) Fr., *W.*, carbonaria Fr., *P.*, fusus (Batsch) Fr., *W.*, sapinea Fr., *N.*, *R.*, *W.*, *P.*, tricholoma (A. & S.) Fr., *F.*, *P.*, scamba Fr., *P.*

Cortinarius (Phlegmacium) varius (Schaeff.) Fr., *W.*, largus Fr., *S.*, multiformis Fr., *S.*, caerulescens Fr., *P.*, croceo-caeruleus (Pers.) Fr., *S.* (Myxacium) elatior Fr., *R.*, *W.*, *S.*, (Inoloma) pholideus Fr., *W.*, (Dermocybe) tabularis (Bull.) Fr., *R.*, *S.*, caninus Fr., *R.*, *S.*, anomalus Fr., *S.*, phoeniceus (Bull.) Maire, *S.*, semisanguineus (Brig.) Maire, *W.*, cinnamomeus (Linn.) Fr., *W.*, (Telamonia) bivelus Fr., *S.*, hinnuleus (Sow.) Fr., *S.*, *P.*, hemitrichus Fr., *W.*, rigidus (Scop.) Fr., *S.*, *P.*, (Hydrocybe) leucopus (Bull.) Fr., *P.*, obtusus Fr., *W.*, decipiens (Pers.) Fr., *W.*
Crepidotus mollis (Schaeff.) Fr., *W.*
Psalliota flavescens Gill., *S.*, campestris (Linn.) Fr., *N.*, sylvicola (Vitt.) Fr., *N.*, *S.*, haemorrhoidaria Kalchb., *F.*, arvensis (Schaeff.) Fr., var. purpurascens Cooke, *S.*, comtula Fr., *W.*
Stropharia aeruginosa (Curt.) Fr., *N.*, *W.*, *P.*, *G.*, squamosa (Pers.) Fr., *S.*, coronilla (Bull.) Fr., *C.*, semiglobata (Batsch) Fr., *P.*
Hypholoma sublateritium (Schaeff.) Fr., *R.*, capnoides Fr., *W.*, fasciculare (Huds.) Fr., *N.*, *R.*, *W.*, *F.*, *P.*, *G.*, epixanthum Fr., *S.*, dispersum Fr., *P.*, velutinum (Pers.) Fr., *W.*, appendiculatum (Bull.) Fr., *W.*, hydrophilum (Bull.) Fr., *N.*, *R.*, *W.*, *S.*
Psilocybe sarcocephala Fr., *R.*, ericaea (Pers.) Fr., *W.*, subericaea Fr., *W.*, uda (Pers.) Fr., *B.*, *P.*, semilanceata Fr., *N.*, *W.*, *P.*, foenisecii (Pers.) Fr., *W.*, *C.*
Psathyra gossypina (Bull.) Fr., *W.*, fibrillosa (Pers.) Fr., *W.*, *S.*
Psathyrella gracilis Fr., *W.*, crenata (Lasch) Fr., *S.*, atomata Fr., *C.*, *F.*
Panaeolus campanulatus (Linn.) Fr., *N.*, *W.*, *F.*
Coprinus comatus (Fl. Dan.) Fr., *F.*, atramentarius (Bull.) Fr., *N.*, micaceus (Bull.) Fr., *N.*, *S.*, lagopus Fr., *N.*, *W.*, *P.*, plicatilis (Curt.) Fr., *C.*, ephemerus (Bull.) Fr., *S.*
Gomphidius viscidus (Linn.) Fr., *N.*, *P.*
Boletus luteus (Linn.) Fr., *R.*, *W.*, elegans (Schum.) Fr., *W.*, *P.*, viscidus (Linn.) Fr., *W.*, granulatus (Linn.) Fr., *N.*, badius Fr., *W.*, *S.*, bovinus (Linn.) Fr., *W.*, piperatus (Bull.) Fr., *W.*, variegatus (Sw.) Fr., *R.*, *W.*, chrysenteron (Bull.) Fr., *N.*, *S.*, *F.*, *P.*, *G.*, subtomentosus (Linn.) Fr., *S.*, *N.*, *F.*, versicolor Rostk., *W.*, pruinatus Fr., *R.*, edulis (Bull.) Fr., *W.*, *P.*, pinicola (Vitt.) Rea, *P.*, reticulatus (Schaeff.) Boud., *W.*, *N.*, calopus Fr., *W.*, erythropus (Pers.) Quél., *N.*, *R.*, *P.*, *W.*, *S.*, duriusculus Schulz., *W.*, versipellis Fr., *R.*, *S.*, *G.*, scaber (Bull.) Fr., *W.*, *S.*, *G.*
Polyporus perennis (Linn.) Fr., *W.*, *P.*, *G.*, brumalis (Pers.) Fr., *S.*, squamosus (Huds.) Fr., *N.*, Schweinitzii Fr., *R.*, *W.*, giganteus (Pers.) Fr., *S.*, *F.*, betulinus (Bull.) Fr., *R.*, *W.*, *P.*, benzoinus (Wahlenb.) Fr., *N.*, adustus (Willd.) Fr., *R.*, *W.*, *S.*, lacteus Fr., *R.*, fragilis Fr., *R.*, *W.*, caesius (Schrad.) Fr., *R.*, stipticus (Pers.) Fr., *N.*, *S.*
Fomes annosus Fr., *N.*, *R.*, *W.*, *S.*, *F.*, *P.* (on birch).
Ganoderma applanatum (Pers.) Pat., *N.*, *S.*
Poria sanguinolenta (A. & S.) Fr., *R.*, hymenocystis B. & Br., *N.*, xantha (Fr.) Lind, *P.*
Polystictus versicolor (Linn.) Fr., *N.*, *W.*, abietinus (Dicks.) Fr., *N.*
Irpex obliquus (Schrad.) Fr., *F.*, *S.*, *G.*
Lenzites betulina (Linn.) Fr., *W.*
Trametes gibbosa (Pers.) Fr., *W.*, rubescens (A. & S.) Fr., on *Salix*, *G.*
Merulius tremellosus (Schrad.) Fr., *W.*, *P.*
Phlebia merismoides Fr., *R.*
Fistulina hepatica (Huds.) Fr., *N.*
Hydnum repandum (Linn.) Fr., *W.*, *G.*, auriscalpium (Linn.) Fr., *R.*, *W.*, *P.*
Mycoleptodon ochraceum (Pers.) Pat., *S.*
Acia uda (Fr.) Bourd. & Galz., *S.*
Grandinia farinacea (Pers.) Bourd. & Galz. *S.*, granulosa Fr., *S.*
Odontia arguta (Fr.) Quél., *R.*, papillosa (Fr.) Bres., *R.*
Thelephora terrestris Ehrh. ex Fr., *N.*, *R.*, *W.*, *F.*, *P.*, *G.*
Hypochnus fuscus (Pers.) Fr., *S.*, *F.*, fumosus Fr., *R.*, *W.*, *F.*

Sparassis crispa (Wulf.) Fr., *W.*, *S.*, *P.*
Stereum spadiceum Fr., *P.*, hirsutum (Willd.) Fr., *N.*, *W.*, *P.*, rugosum (Pers.) Fr.,
    R., *W.*, *P.*, purpureum Pers. ex Fr., *S.*, *P.*
Hymenochaete Mougeotii (Fr.) Cooke, *N.*, *R.*
Corticium fuciforme (Berk.) Wakef., *N.*, *W.*, arachnoideum Berk., *R.*, Sambuci
    (Pers.) Fr., *N.*, subcoronatum v. H. & Litsch., *R.*, confine Bourd. & Galz.,
    R., *S.*, praetermissum (Karst.) Bres., *S.*
Peniophora byssoidea (Pers.) v. H. & Litsch., *W.*, velutina (DC.) Cooke, *S.*,
    setigera (Fr.) Bres., *S.*, hydnoides Cooke & Mass., *R.*, *S.*, gigantea (Fr.) Mass.,
    N., *W.*, incarnata (Pers.) Cooke, *S.*, *W.*, quercina (Pers.) Cooke, *N.*, *P.*
Cyphella capula (Holmsk.) Fr., *S.*
Solenia anomala (Pers.) Fr., *N.*
Clavaria cristata (Holmsk.) Fr., *R.*, cinerea (Bull.) Fr., *S.*, rugosa (Bull.) Fr., *R.*,
    W., inaequalis (Mull.) Fr., *N.*, fistulosa (Holmsk.) Fr., *S.*, *R.*, *W.*
Pistillaria quisquiliaris Fr., *R.*, *S.*, puberula Berk., *W.*, *S.*
Auricularia auricula-Judae (Linn.) Schroet., *R.*
Exidia glandulosa (Bull.) Fr., *S.*
Tremellodon gelatinosum (Scop.) Pers., *R.*, *S.*
Sebacina incrustans (Pers.) Tul., *P.*, *S.*
Dacryomyces deliquescens (Bull.) Duby, *N.*, *W.*, *S.*
Calocera viscosa (Pers.) Fr., *R.*, *S.*, *F.*, *P.*, cornea (Batsch) Fr., *R.*, stricta Fr., *R.*

GASTEROMYCETES

Cynophallus caninus (Huds.) Fr., *W.*, *P.*, *S.*
Phallus impudicus (Linn.) Pers., *N.*, *R.*, *P.*, *S.*
Lycoperdon saccatum (Vahl) Fr., *W.*, *S.*, umbrinum Pers., *W.*, *S.*, perlatum Pers.,
    W., *S.*, *N.*, pyriforme (Schaeff.) Pers., *S.*, *P.*
Bovistella paludosa (Lév.) Lloyd, *B.*
Geaster triplex Jungh., *S.*
Crucibulum vulgare Tul., *R.*, *S.*, *F.*
Cyathus striatus (Huds.) Pers., *S.*
Scleroderma aurantium Pers., *N.*, *W.*, *P.*
Sphaerobolus stellatus (Tode) Pers., *R.*, *S.*, *P.*

UREDINALES

Uromyces Rumicis (Schum.) Wint., *N.*, *G.*, Acetosae Schroet., *N.*, Valerianae
    (Schum.) Fuck., *B.*, *G.*
Puccinia calthaecola Schroet. on *Caltha palustris*, *B.*, *G.*, Thalictri Chev., *G.*, Violae
    (Schum.) DC., *W.*, *P.*, aegra Grove, *F.*, *G.*, Lychnidearum Link, *N.*, Mal-
    vacearum Mont., *C.*, Cicutae Lasch, *G.*, Hydrocotyles (Link) Cooke, *W.*,
    Saniculae Grev., *S.*, Centaureae Mart., *N.*, obtegens (Link) Tul., *F.*, Hypo-
    chaeridis Oud., *B.*, Antirrhini Diet. & Holw., *F.*, *C.*, Glechomatis DC., *N.*,
    C., *P.*, Menthae Pers., *R.*, *G.*, annularis (Str.) Schlecht., *N.*, *R.*, *W.*, *B.*,
    Polygoni A. & S., *S.*, Buxi DC., *N.*, Caricis (Schum.) Rebent., *G.*, Lolii Niels.,
    C., Magnusiana Körn., *G.*, Phragmitis (Schum.) Körn., *G.*, Poarum Niels.,
    aecidium on *Tussilago*, *S.*, mirabilissima Peck, *F.*, *P.*
Phragmidium violaceum (Schultz.) Wint., *N.*, *W.*, Rubi (Pers.) Wint., *G.*
Kuehneola albida (Kuehn.) Magn., *N.*, *W.*, *F.*, Tormentillae (Fuck.) Arth.,
    W., *B.*
Coleosporium Euphrasiae (Schum.) Wint., *B.*, Senecionis (Pers.) Fr., *W.*, *C.*,
    Tussilaginis (Pers.) Kleb., *S.*
Cronartium asclepiadeum Fr. on *Tropaeolum majus*, *F.*
Pucciniastrum Agrimoniae (DC.) Tranzsch., *S.*, *G.*, Epilobii (Pers.) Otth, *W.*, *R.*,
    S., *P.*, *F.*
Melampsoridium betulinum (Pers.) Kleb., *W.*, *R.*, *P.*, *S.*
Milesina Blechni Syd., *W.*

USTILAGINALES

Ustilago Lychnidis-dioicae (DC.) Liro, *N.*, *R.*, longissima (Schlecht.) Meyen, *G.*,
   utriculosa (Nees) Tul. on *Polygonum hydropiper*, *G.*
Sphacelotheca Hydropiperidis (Schum.) de Bary, *C.*
Tilletia striaeformis (West.) Wint., *P.*

PLECTASCALES

Ctenomyces serratus Eidam, *R.*
Elaphomyces granulatus Fr., *W.*

PYRENOMYCETES

Sphaerotheca Humuli (DC.) Burr. on *Arctium*, *P.*, on *Epilobium*, *G.*, pannosa
   (Wallr.) Lév., *N.*
Erysiphe Polygoni DC. on *Delphinium*, *N.*, on Swede, *N.*
Microsphaera Grossulariae (Wallr.) Lév., *P.*
Uncinula Aceris (DC.) Sacc., *R.*, *P.*
Phyllactinia corylea (Pers.) Karst. on *Corylus*, *W.*, *P.*
Gibberella pulicaris (Fr.) Sacc. on Broom, *Mousehold Heath*.
Nectria cinnabarina (Tode) Fr., conidial only, on *Ilex*, *W.*, on *Ulex*, *S.*, Desmazierii
      de Not. on *Buxus*, *N.*, Aquifolii (Fr.) Berk. on *Ilex*, *S.*, punicea (Kunze &
      Schm.) Fr. on *Ilex*, *S.*
Hyponectria Buxi (Desm.) Sacc. on *Buxus*, *N.*
Hypocrea pulvinata Fuck. on *Polyporus betulinus*, *P.*
Claviceps microcephala (Wallr.) Tul., *S.*
Cordyceps ophioglossoides (Ehrh.) Link, *W.*, capitata (Holmsk.) Link, *R.*, *W.*
Lasiosphaeria hirsuta (Fr.) Ces. & de Not., *G.*
Leptospora ovina (Pers.) Fuck., *S.*
Diaporthe eres Nits. on *Ulex*, *S.*, fibrosa (Pers.) Fuck. on *Rhamnus cathartica*, *G.*,
      leiphaemia (Fr.) Sacc. on *Quercus*, *S.*
Peroneutypa heteracantha (Sacc.) Berl. on *Acer*, *N.*
Cryptosphaeria eunomia (Fr.) Fuck. on *Fraxinus*, *G.*
Melanconis stilbostoma (Fr.) Tul. on *Betula*, *W.*
Pseudovalsa lanciformis (Fr.) Ces. & de Not. on *Betula*, *R.*
Diatrype disciformis (Hoffm.) Fr. on *Acer*, *N.*, on *Carpinus*, *S.*, Stigma (Hoffm.) Fr.
   on *Carpinus*, *S.*
Hypoxylon coccineum Bull. on *Fagus*, *W.*, argillaceum (Pers.) Fr. on *Fraxinus*, *G.*,
      multiforme Fr. on *Pyrus Aucuparia*, *S.*, semiimmersum Nits. on *Quercus*, *W.*
Daldinia concentrica (Bolt.) Ces. & de Not., *F.*
Xylaria Hypoxylon (Linn.) Grev., *W.*, *S.*, *P.*, polymorpha (Pers.) Grev., *N.*, *S.*, *P.*,
      Tulasnei Nits. on rabbit dung, *W.*
Phyllachora graminis (Pers.) Fuck. on *Dactylis*, *N.*
Rhopographus filicinus (Fr.) Nits., *N.*, *P.*

HYSTERIALES

Gloniopsis curvata Sacc. on *Fraxinus*, *G.*
Hysterium angustatum A. & S. on *Fraxinus*, *G.*

DISCOMYCETES

Helvella crispa (Scop.) Fr., *R.*, *W.*, *S.*, *F.*, lacunosa Afz., *S.*
Macropodia macropus (Pers.) Fuck., *W.*
Rhizina inflata (Schaeff.) Karst., *P.*
Galactinia badia (Pers.) Boud., *W.*, *P.*
Otidea onotica (Pers.) Fuck., *N.*
Geopyxis carbonaria (A. & S.) Sacc., *P.*
Peziza aurantia Pers., *N.*, *R.*

Pulvinula constellatio (Cooke) Boud., *S.*
Saccobolus violascens Boud., *S.*
Taphrina Tosquinetii (West.) Magn., *W.*
Leotia lubrica (Scop.) Pers., *W.*
Cudoniella acicularis (Bull.) Schroet., *R.*, *S.*
Coryne sarcoides (Jacq.) Tul., *W.*, *S.*
Bulgaria inquinans (Pers.) Fr., *N.*, *P.*
Corynella atrovirens (Pers.) Boud., *S.*
Orbilia xanthostigma Fr., *W.*
Phialea echinophila (Bull.) Quél., *S.*, firma (Pers.) Gill., *S.*
Chlorosplenium aeruginosum (Oeder) de Not., *S.*, on beech.
Helotium fructigenum (Bull.) Fuck., *R.*, *S.*
Trichoscypha calycina (Schum.) Boud., *W.*
Mollisia cinerea (Batsch) Karst., *S.*, *P.*
Phacidium multivalve (DC.) Kunze & Schm., *W.*
Stegia Ilicis Fr., *W.*, *S.*
Rhytisma acerinum (Pers.) Fr., *N.*, *F.*, *P.*

PHYCOMYCETES

Syzygites megalocarpus Ehrenb., *W.*, *S.*
Bremia Lactucae Regel, *S.*
Plasmopara nivea (Unger) Schroet., on *Aegopodium*, *P.*
Peronospora alta Fuck., on *Plantago*, *F.*
Entomophthora echinospora Thaxter, on fly, *P.*

DEUTEROMYCETES

Dendrophoma pruinosa (Fr.) Sacc. on *Fraxinus*, *G.*
Actinonema Rosae (Lib.) Fr., *N.*
Eleutheromyces subulatus (Tode) Fuck. on *Sparassis*, *W.*
Septoria Violae West. on *Viola Riviniana*, *W.*
Cylindrium flavovirens Bon., *R.*
Trichoderma viride Fr., *N.*
Rhinotrichum Thwaitesii B. & Br., *W.*, *P.*
Sepedonium chrysospermum (Bull.) Fr., *N.*, *R.*
Ovularia obliqua (Cooke) Oud., *S.*, *P.*, haplospora (Speg.) Magn. on *Alchemilla arvensis*, *N.*
Botrytis cinerea Pers., *R.*
Cephalosporium coccorum Petch, on Mealy Bugs, *S.*
Acremonium album Preuss on *Stemonitis*, *S.*
Gliocladium penicillioides Corda on *Gibberella*, *Mousehold Heath.*
Chalara fungorum Sacc. on *Eleutheromyces*, *W.*
Ramularia Urticae Ces., *W.*, acris Lindr. on *Ranunculus acris*, *P.*, Tulasnei Sacc., *S.*, calcea (Desm.) Ces., *N.*, *R.*, *F.*, *P.*, sambucina Sacc., *N.*, *P.*, Primulae Thuem., *N.*
Napicladium arundinaceum (Corda) Sacc., on *Phragmites*, *G.*
Stilbella erythrocephala (Ditm.) Lindau, *N.*, *F.*, *W.*
Tilachlidium tomentosum (Schrad.) Lindau, on *Cribraria*, *R.*, *W.*, *S.*, on *Comatricha*, *R.*
Isaria (Tilachlidium) brachiata (Batsch) Schum., on decaying Agaric, *R.*, (Spicaria) farinosa (Holmsk.) Fr., on pupae, *R.*, *W.*, *P.*
Gibellula aranearum (Schw.) Syd. on spider, *P.*
Sporocybe Azaleae Peck, *N.*, *W.*
Tuberculina persicina (Ditm.) Sacc., on *Puccinia Poarum*, *S.*, on *P. Antirrhini*, *Norwich.*
Volutella Buxi (Corda) Berk., *P.*
Anthina flammea Fr., *S.*
Ectostroma Iridis (Ehrenb.) Fr. on *Iris pseudacorus*, *G.*

MYCETOZOA FOUND DURING THE NORWICH FORAY

By H. J. HOWARD

THE summer had been characterised by conditions unfavourable to the development of Mycetozoa, but a week's rain previous to the foray and rain at the end of almost every day caused several species to appear and a total of thirty-six was recorded.

October 2nd. A visit was made to Northrepps Hall Woods, which consist chiefly of beech with very few old logs: nothing of outstanding importance was gathered. The afternoon, spent in West Runton woods where a number of pine logs were present, produced *Tubifera ferruginosa* and *Cribraria vulgaris*.

October 3rd was a dull day and the extensive Westwick woods were visited: these consist of heathland, with pine wood and *Sphagnum* under birches. It is probable that it was on this day that the new British record of *Physarum javanicum* was made by Miss Cayley, who collected this species on bark with *Parmelia* sp. Owing to its superficial resemblance to *Physarum nutans* it was taken for that species, but on being sent to Miss Lister the discoid sporangia with the deposits of lime uniformly distributed in the walls and not clustered to form spots as in all varieties of *P. nutans* led to its identification. Later in the afternoon the North Walsham woods were explored in the same neighbourhood.

October 4th. Stratton Strawless woods, with mixed growth of beech, birch, hornbeam, oak, chestnut, bramble and bracken, with numerous clearings, yielded a variety of Mycetozoa. The journey was continued to Buxton Heath, but a rain storm prevented extensive searching there.

October 5th. Sprowston and Plumstead Road Woods and Framingham Chase proved somewhat unfruitful. The afternoon, however, provided an interesting diversion, for a chance meeting with Mr J. Morse of Eaton resulted in a visit to his cucumber-houses where *Physarum gyrosum* was seen in abundance, both in the plasmodium and fruiting stages. Sticks, soil and stems of cucumbers were covered with rosettes of this species and sometimes the considerable patches of plasmodium had crept up the pots standing upon the soil. This species has occurred in these glasshouses in great abundance on several occasions and, it is interesting to note, always in houses manured with sewage sludge and never in others adjacent treated with farmyard manure. A piece of soil covered with creamy white veins of plasmodium was taken home which next day was found to have changed

to "clear Amazonite blue" as described by M. K. Minakata from Tanabe, Japan. Unfortunately instead of being allowed to mature naturally, the mass was placed in a very moist incubator in order to imitate the conditions of the cucumber house, and the temperature being too high, the plasmodium was injured and turned to a blood-red colour in drying. I am inclined to think that the plasmodium normally changes to blue before forming sporangia, but hope to make confirmatory observations should the species appear again. *Fuligo septica* var. *candida* was also found maturing upon cucumber stems.

N. = Northrepps Hall Woods; *R.* = West Runton Woods; *W.* = Westwick and North Walsham Woods; *S.* = Stratton Strawless Woods; *P.* = Sprowston and Plumstead Road Woods; *F.* = Framingham Chase; *E.* = cucumber houses at Eaton, Norwich.

Ceratiomyxa fruticulosa (Muell.) Macbr., *N.*, pine wood.
Badhamia utricularis Berk., *S.*, dead pine wood.
Physarum nutans Pers., *N.*, *W.*, dead wood, var. leucophaeum Lister, *S.*, *F.*, dead wood.
P. javanicum Racib., *W.*?, bark with lichen.
P. gyrosum Rost., *E.*, soil, stems, pots, in cucumber houses.
P. bitectum Lister, *W.*, old larch.
Fuligo septica (L.) Gmel., *N.*, *R.*, *W.*, *F.*, dead wood, var. candida Lister, *N.*, pine wood, *E.*, cucumber stems.
Craterium minutum (Leers) Fr., *W.*, *S.*, dead leaves, etc.
C. leucocephalum Ditm., *W.*, holly leaves.
Leocarpus fragilis (Dicks.) Rost., *W.*, *S.*, beech leaves, twigs.
Diderma hemisphericum (Bull.) Hornem., *W.*, twigs and alder leaves.
Diachaea leucopoda Rost., *S.*, twigs and leaves.
Didymium difforme (Pers.) Duby, *W.*, dead leaves.
D. Clavus (A. & S.) Rost., *N.*, *S.*, dead leaves.
D. melanospermum (Pers.) Macbr., *W.*
D. nigripes Fr. var. xanthopus Lister, *W.*, *S.*, alder twigs, etc.
Mucilago spongiosa (Leysser) Morg., *W.*, *S.*, grass.
Stemonitis fusca Roth, *W.*, *S.*, dead wood.
S. splendens Rost. var. flaccida Lister, *W.*, alder.
S. herbatica Peck, *R.*, twigs and leaves.
S. flavogenita Jahn, *S.*, *P.*
Comatricha nigra (Pers.) Schroet., *W.*, *S.*, *P.*, birch, etc.
C. typhoides (Bull.) Rost., *S.*, dead wood.
Enerthenema papillatum (Pers.) Rost., *W.*, *S.*, *P.*, dead wood.
Cribraria argillacea Pers., *S.*, dead wood.
C. rufa (Roth) Rost., *R.*, pine wood.
C. vulgaris Schrad., *R.*, *W.*, *S.*, *F.*, pine wood, var. aurantiaca Pers., *R.*, *S.*, pine wood.
Licea flexuosa Pers., *N.*, *S.*, green slimy pine log, etc.
Tubifera ferruginosa Gmel., *N.*, *R.*, *W.*, *S.*, *F.*, dead pine wood.
Lycogala epidendrum Fr., *E.*, twigs in cucumber house.
Trichia persimilis Karst., *N.*, dead wood.
T. varia Pers., *W.*, *S.*, dead birch, etc.
Arcyria cinerea (Bull.) Pers., *W.*, *F.*, dead wood.
A. denudata Wettst., *W.*, *S.*, birch, etc.
A. incarnata Pers., *N.*, *R.*, *W.*, *S.*, dead wood.
A. nutans (Bull.) Grev., *R.*, dead wood.

NORFOLK LICHENS

By H. H. KNIGHT

THE Norfolk woods visited during the Foray were not very rich in lichens, and in the woods near Norwich visited on Friday, particularly those of Sprowston and Plumstead, the trees were very bare. *Graphis elegans* and *scripta* were seen in Stratton Strawless woods, but nowhere else, and no species of *Opegrapha* was seen on trees. *Lecidea lucida* occurred on a brick wall in the woods near Overstrand. This is a lichen which appears to be spreading from its natural habitat on siliceous rocks to brick walls, and is sometimes found even on town walls in the Midlands.

On October 6th I visited the Marams near Blakeney with Dr Watson. On the stones here a number of saxicolous lichens were found. *Physcia ciliaris*, usually a tree lichen, was growing on the ground, and *Placodium luteoalbum*, which prefers elms, was growing on the stems of *Suaeda fruticosa*.

In the following list I have as usual followed the order and naming of the *Monograph of the British Lichens*, by Miss A. Lorrain Smith. Without the help of Dr Watson the list would have been much shorter.

O. = Overstrand and Runton Woods; W. = Westwick and North Walsham Woods; S. = Stratton Strawless Woods; B. = Walls and trees near Woodrow Inn and Buxton Heath; P. = Plumstead and Sprowston Woods; F. = Framingham Woods; M. = The Marams near Blakeney and walls near Cley; C. = Common lichens.

Chaenotheca melanophaea Zwackh., S., F.
Calicium hyperellum Ach., S., M.
Cyphelium inquinans Trev., O.
Peltigera canina Willd., O., W., M.
P. polydactyla Hoffm., W., F.
Parmelia physodes Ach., C.
  var. platyphylla Ach., F.
P. perlata Ach., O., S.
P. caperata Ach., W., S., F.
P. subaurifera Nyl., S.
P. sulcata Tayl., C.
P. dubia Tayl., S.
P. revoluta Floerke, W., S.
P. acetabulum Dub., F.
P. fuliginosa Nyl., F., M.
  var. laetevirens Nyl., C.
Cetraria aculeata Fr., M.
Evernia prunastri Ach., C.
Ramalina calicaris Fr., S.
R. fastigiata Ach., S.

Ramalina farinacea Ach., C.
R. pollinaria Ach. f. humilis Cromb., B., F.
Xanthoria parietina Th. Fr., C.
  var. aureola Th. Fr., S., M.
X. polycarpa Oliv., W., M.
X. lychnea Th. Fr., B., F.
Placodium flavescens A. L. Sm., M.
P. murorum DC., B., M.
  var. pusillum Flag., M.
P. lobulatum A. L. Sm., M.
P. citrinum Hepp, B., M.
P. phloginum A. L. Sm., S.
P. aurantiacum var. flavovirescens Hepp, M.
P. luteoalbum Hepp, M.
P. atroflavum A. L. Sm., M.
Candelariella vitellina Müll.-Arg., C.
Physcia ciliaris DC., M.
P. pulverulenta Nyl., M.
P. grisea A. Zahlbr., S.

Physcia hispida Tuckerm., *S.*, *M.*
P. caesia Nyl., *B.*
P. orbicularis var. virella Dalla Torre
    & Sarnth., *B.*, *M.*
Rinodina demissa Arn., *M.*
R. umbrinofusca Oliv., *M.*
Lecanora muralis Schaer., *B.*
L. subfusca Ach., *O.*, *P.*
    var. chlarona Ach., *S.*, *F.*
    var. allophana Ach., *S.*
L. rugosa Nyl., *S.*
L. intumescens Koerb., *P.*
L. campestris B. de Lesd., *B.*, *M.*
L. atra Ach., *M.*
L. Hageni Ach., *S.*, *F.*, *M.*
L. umbrina Massal., *M.*
L. galactina Ach., *B.*, *M.*
L. dispersa Nyl., *M.*
L. varia Ach., *C.*
L. conizaea Nyl., *F.*
    var. conizaeoides A. L. Sm., *S.*, *P.*, *F.*
L. symmictera Nyl., *B.*, *F.*, *M.*
L. expallens Ach., *S.*
Lecania prosechoides A. L. Sm., *M.*
L. erysibe Mudd, *M.*
Pertusaria globulifera Nyl., *S.*
P. faginea Leight., *C.*
P. pertusa Dalla Torre & Sarnth., *C.*
Phlyctis agelaea Koerb., *S.*, *F.*
Baeomyces rufus DC., *W.*, *F.*
Cladonia sylvatica Hoffm., *O.*, *B.*
C. foliosa Willd., *M.*
C. pyxidata Hoffm., *C.*
    var. chlorophaea Floerke, *S.*, *F.*
C. fimbriata Fr., *C.*
    var. simplex Wain., *F.*
    var. radiata Cromb., *S.*, *F.*
    var. subcornuta Nyl., *F.*
C. ochrochlora f. ceratodes Floerke, *B.*
C. pityrea Fr., *B.*
C. crispata Flot., *B.*

Cladonia furcata Schrad., *C.*
    var. spinosa Leight., *M.*
    var. recurva Hoffm., *B.*
C. rangiformis Hoffm., *M.*
    var. foliosa Wain., *M.*
C. squamosa Hoffm., *S.*
C. digitata Hoffm., *W.*, *F.*
C. coccifera Willd., *B.*
C. flabelliformis Wain., *F.*
C. macilenta Hoffm., *B.*, *F.*
C. Floerkeana Fr. var. carcata Wain., *B.*
Gyalecta diluta Wain., *P.*, *F.*
Lecidea lucida Ach., *O.*
L. coarctata Nyl., *F.*
L. quernea Ach., *S.*
L. granulosa Schaer., *C.*
L. flexuosa Nyl., *W.*
L. uliginosa Ach., *S.*
L. fuliginea Ach., *S.*
L. dubia Hook., *M.*
L. expansa Nyl., *M.*
Biatorina Griffithii Massal., *S.*, *P.*, *F.*
B. erysiboides Th. Fr., *F.*
B. Lightfootii var. commutata Mudd, *S.*
B. lenticularis Koerb., *M.*
B. chalybeia Mudd, *M.*
Bacidia phacodes Mudd, *S.*
Buellia canescens De Not., *B.*, *M.*
B. myriocarpa Mudd, *B.*, *M.*
B. stellulata Mudd, *M.*
B. confervoides Kremp., *M.*
Rhizocarpon confervoides DC., *M.*
Graphis elegans Ach., *S.*
G. scripta Ach., *S.*
Verrucaria maura Wahlenb., *M.*
V. microspora Nyl., *M.*
V. viridula Ach., *B.*, *M.*
V. nigrescens Pers., *M.*
V. mutabilis Borr., *F.*
V. muralis Ach., *F.*
Acrocordia epipolaea A. L. Sm., *B.*

PRESIDENTIAL ADDRESS

By B. BARNES, D.Sc., Ph.D., F.L.S.

INDUCED VARIATION

PROBABLY ever since man has concerned himself with domesticated plants and animals, he has tried to improve his stocks. Much success has been attained by judicious selection and by systematic breeding from chance variations of a desirable kind which turned up in the animals and plants, and efforts have been made by artificial means to provoke variations. There is a traditional method of obtaining variation by the simultaneous use of high feeding, relatively high temperatures and crowding; this method seems to have been effective in dealing with cultivated plants, and the Chinese are said to have brought about much alteration in gold fish by keeping them in confined spaces in dirty conditions. Darwin, in his *Variation under Domestication*,* refers to the general opinion among plant breeders that a stock of plants must be grown on poor land if it is to be kept true. Such ideas, widely held by practical men whose living depends on success with their plants and animals, must be based on a good deal of experience, and cannot be disregarded, but the traditional methods appear to be slow and capricious in their operation, and do not seem capable of much control.

In the second half of the nineteenth century, some scattered work was done on the experimental induction of variation, but at that time there was little sympathy with any work which tended to upset the idea of the fixity of species, a somewhat strange position, since variability, and very great variability, was accepted without difficulty in domesticated creatures. A growing realisation that experiment was necessary in order to get a better understanding of the mechanism of evolution, and the development of Mendelism, combined to awaken interest in variation, and stimulated efforts to discover if the rate of change in organisms could be influenced by direct treatment with physical or chemical agents, since the successful outcome of such experiments might well throw light on the nature of evolutionary changes, and also free the breeder from the necessity of waiting until some chance variant fell into his hands. Up to the present, we have not made much progress in elucidating the mysteries of evolution, and it is not clear that the breeder has been much helped, but a number of workers, using many kinds of plants and animals, have shown, during the present century, that changes can be induced by the use of chemicals, by the application of high tem-

* Darwin, C., *Variation under Domestication*, II (1905), 300–3. London: Murray.

peratures, by dosage with X-rays and with emanations from radium, by exposure to ultra-violet light, and, probably, by taking advantage of some slow changes going on within the organisms. There is no evidence at present that any of the agents found to be effective have any specific effect; similar variations have been induced in the same stock of the same organism after treatment with high temperatures or after exposure to X-rays. The experimental results have been and continue to be erratic, since the work is difficult, and since, so far, no one has invented a technique capable of exact application. Even with such simple things as bacteria and fungal spores, it is impossible to be sure that the material is homogeneous and that the treatment is evenly applied; with seeds of the higher plants, with growing plants, and with the eggs, and other developmental stages of animals, standardisation of the experimental material is impossible. Although as yet we have no means of repeating an experiment with a reason- able expectation of repeating the results of previous similar experi- ments, the failure of one worker to repeat exactly the work of another does not mean that the results of either are valueless.

The simple organisation of the fungi, and the ease with which they are grown in pure culture, makes these organisms very suitable sub- jects for experiments on induced variation, and fungi have afforded as satisfactory evidence as have any group of organisms that variation can be induced. Hansen,[*] well known for his work on yeasts, pro- duced the first good evidence of the induction of variation in a fungus. He developed a sound technique for the isolation of single cells, and for the maintenance of pure cultures started from single cells. After he had shown that yeasts continued to bud at a temperature a few degrees higher than the maximum temperature at which they could form spores, Hansen succeeded in producing a non-sporing race from a richly sporing stock of a wine yeast (Johannisberg II of Wortmann, probably a form of *Saccharomyces ellipsoideus*) by prolonged culture at a temperature between the maximum for spore formation and the maximum for budding. The original material lost the power of sporu- lation gradually, but, after working for about three months with cultures which were renewed every few days, he obtained a race which did not form spores, no matter how it was fed or treated; this race was kept in culture for sixteen years, and during that time did not regain the power of sporulation. Since the original yeast was dis- tinguished by its rich sporulation, and since Hansen could never show that it produced non-sporing cells in ordinary culture, he fairly con- cluded that the asporogenous race had come into existence because his experiments had caused a change, and that it had not been grown from a non-sporing cell present in the original material, and acci- dentally selected as a starting point for the cultures.

* Hansen, E. C., *C.R. Lab. Carlsberg*, II (1883), ii; *Ann. Bot.* IX (1895), 549.

Aspergillus niger has long been a favourite subject for experiments with fungi; a Continental writer once called it the mycologist's guinea-pig. *A. niger* has yielded induced variants after exposure to high temperatures, and after treatment with chemicals. In 1912, Schiemann* gave a very thorough account of changes produced in a stock of the fungus, a stock well known to be constant in ordinary culture. She distinguished carefully between modifications due to the use of special conditions, and only appearing so long as the special conditions were operative, and true permanent changes. For example, media containing copper sulphate in a concentration of 1/1000, and known to be of a kind very favourable to the growth of the fungus when copper sulphate was not present, bore weak whitish colonies with poor crops of conidia; these weak colonies were however nothing more than modifications, for, conidia taken from them and planted on ordinary media yielded the normal *A. niger* at once. On the other hand, the addition of potassium bichromate to the medium sometimes caused the appearance of a true variant. It was found that although some growth was possible on media containing potassium bichromate in a concentration greater than 1/2000, such concentrations prevented the forming of conidia. On media whose content of the salt was just below that necessary to prevent sporulation, germination was greatly delayed (taking sixteen days instead of about a day), and fruiting was tardy (needing twenty-eight days instead of three to four). One of the first cultures made on a medium of this kind yielded some rusty brown conidial heads among the normal blackish heads, and the light-coloured heads yielded a variant which was still alive in culture in 1929, and may be so still, developing its light-coloured heads on ordinary media, free from bichromate. The early isolations of the variant, on ordinary media, showed colour fluctuations about the average chocolate-brown, but these fluctuations were inconstant and could not be transmitted to further cultures. Such initial instability is a common feature when variants are settling down after their first appearance.

A cinnamon-brown variant appeared after *A. niger* had been passed through eleven successive cultures on a medium containing potassium bichromate in a concentration of 1/20,000; the early isolations were unstable, and went through several transfers before settling into a permanent variant.

Schiemann also tried the effects of high temperatures. When *A. niger* was grown on an ordinary medium at 40–45° C., the growth was specially dense, the conidiophores were dwarfed, and other irregularities were noted; transfers from these cultures to an ordinary medium kept at 36° C., a temperature specially favourable to the growth of the fungus, always gave the normal form. Some cultures

* Schiemann, E., *Zeitschr. f. induk. Abstamm. u. Vererb.* VIII (1912), 1.

were heated for a time to 48° C., and this treatment led to the appearance of true variants. From one of these cultures, a form was isolated showing characters the reverse of those shown by the high-temperature modifications of the species, for the variant grew loosely, produced conidiophores two to three times as long as normal conidiophores, and bore conidial heads slightly larger than normal heads. It follows that modifications due to some special treatment are not necessarily steps towards the formation of a permanent variant under the influence of similar treatment.

Another heated culture produced a greyish head of conidia, and these conidia, planted out separately, yielded some colonies in which sectors appeared, the sectors fruiting later than the rest of the colony. Isolations from the sectors gave a form whose behaviour was inconstant; the first colonies grew weakly and irregularly, but as successive cultures were made, the fungus slowly gained strength. The colonies of this variant were very sensitive to slight differences in the composition and the moisture content of the medium, giving modifications readily, and, in this respect, the variant was more responsive than the stock strain of *A. niger*. The variant germinated and grew well at temperatures too low for the best growth of the parent strain, and was always late in sporing. Young colonies produced greyish brown conidial heads, but on older colonies pigmentation was usually normal. Transfers from young colonies gave the unstable variant; transfers from old colonies gave normal *A. niger*. These phenomena are of special interest; they suggest that the variant was not much altered, and that it had suffered a mild amount of change from the heating, so mild that recovery was possible after a mycelium had grown for a time. Abnormalities in youth followed by an apparent resumption of normal features at a later stage have been encountered in the induced variants of other organisms.

Schiemann's work shows clearly that a given species may be made to yield a series of forms ranging from modifications depending solely for their appearance on special conditions of culture, to pronounced variants with a great degree of permanence.

Waterman* encountered variation in *A. niger* during an attempt to discover substances which were specially good sources of carbon for the fungus. One such substance, para-oxybenzoic acid, used in conjunction with the necessary mineral salts, was found at first to serve the fungus well, and to lead to the storage of much glycogen within the hyphae. Discrepancies began to appear in the chemical determinations however, and these were traced to the formation of variants under the influence of the para-oxybenzoic acid. *A. niger* was also found to vary after treatment with substances which checked its growth, so that both substances apparently favourable to growth and

* Waterman, H. J., *Z. GärPhysiol.* III (1913), 1.

substances certainly unfavourable to growth led to the development of variants. An example such as this indicates the complexity of the position and suggests that the mechanism underlying induced variation can hardly be reduced to one universal explanation.

Haenicke* isolated light-coloured forms of *A. niger* from cultures which had been kept at 45° C.; one was accidentally killed after it had lasted through nine transfers, the other suddenly reverted to normal after retaining its aberrant characters through eighteen successive cultures.

Between 1926 and 1932, many experiments were made† on the effect of high temperatures on *Eurotium herbariorum, Botrytis cinerea* and *Thamnidium elegans*. Well established strains of the three species were available, all known to be constant under ordinary conditions of culture. Spores taken from pure cultures, with precautions to avoid contamination, were heated in various ways and then planted on the usual media; at the same time unheated spores were planted on other dishes of the same media. The experiments yielded a considerable number of variants from the heated spores, while none was seen in the cultures from unheated spores. Since, during some years of culture, the three stocks had never thrown aberrant forms, it seems a fair conclusion that the development of variants in cultures started from heated spores must be due to the treatment given to the spores. *Eurotium herbariorum* responded best to treatment, no doubt because it offered the most possibilities for change, for the strain used readily formed conidia and perithecia in culture. Some of the variants were slight, and apparent only in young colonies; most of the slight variants reverted sooner or later to the normal form, persisting even in young colonies only through a few transfers. At the other end of the scale, some of the variants obtained in 1926 were still in existence, unchanged, in 1933, having kept their characters through more than 140 transfers made on ordinary media and started from unheated spores. The changes affected the rate of growth, the colour and morphology of the conidia and conidiophores, the colour, form and abundance of the perithecia, the form of the ascospores, and indeed every obvious morphological character of the fungus was changed in one variant or another; though the matter was not investigated systematically, variations in staling capacity, and variations in the extent to which the medium was stained, suggested that physiological characters had also been altered. Some variants were slightly unstable, with a tendency to sectoring, and, in one, sectoring was certainly stimulated by a change of medium. Isolations from these sectors gave another variant, evidently a weakened version of the first; it remained

* Haenicke, A., *Z. Bot.* VIII (1916), 225.
† Barnes, B., *Ann. Bot.* XLII (1928), 783; XLIV (1930), 825; *Trans. Brit. mycol. Soc.* XIX (1935), 291.

distinct from its parent for some eighteen months, but slowly reverted to the form of the original variant, but not to that of the stock *Eurotium herbariorum*. A brown variant was particularly distinguished by the heavy production of a sterile, white aerial mycelium on old colonies. Another, with conidia not greatly different in colour from those of the normal form, always showed some deformations of the conidial apparatus and never developed perithecia; this variant, and another which formed but few perithecia, stained the medium heavily. It was not possible to demonstrate that there was any general tendency in the variants for characters to be changed in groups, though variants which were able to develop good crops of perithecia seldom produced much aerial mycelium, and they also showed little tendency to stale, or to stain the medium.

Botrytis cinerea offered less possibility of change; alterations were remarked in the general habit, in the form, colour and abundance of the sclerotia, and in the morphology of the conidial apparatus. Some of the variants were extremely unstable when first isolated, and one notable variant was sterile, very weak, and so deficient in strength that it died out after a few transfers. Other variants remained recognisable for more than two years, gradually reverting to normal as time went on, and still others, in particular one that formed dense white colonies, appeared to be permanent. Staining of the medium and the production of much whitish aerial mycelium was most apparent in the variants which developed few or no sclerotia, and if the reasonable assumption be made that the sclerotia of *Botrytis* have some relation to sexual phenomena, we then have in these variants a parallel with some variants of *Eurotium herbariorum*.

Variants of *Thamnidium elegans* were obtained from heated sporangiospores, and they too showed a range from transient to apparently permanent forms. Partial sterility and increase of aerial mycelium characterised the more stable variants, but despite very marked alterations in morphology, all attempts to demonstrate any effect on the sexual reactions, by growing the variants in contrasted cultures, were fruitless; thus, in Zygomycetes, a difference in morphology between two strains of a heterothallic species does not necessarily indicate a difference in sexual character.

An attempt was made during the investigation of the three species just discussed, to establish a relation between the severity of the initial heating and the frequency of variation, and between the severity of treatment and the degree of alteration. Conclusive evidence was not obtained, for many thousands of experiments would be needed to settle the point, but it appeared that exposure to heat just insufficient to kill the spores was most likely to produce the greatest number of striking alterations.

Experiments with heated ascospores of *Eurotium herbariorum* did not

succeed. Bean and Brooks* were unable to cause variation in *Pyronema confluens* by heating the ascospores, and Dickson† had the same experience with the ascospores of *Chaetomium cochliodes*, though he found that these spores produced many variants after treatment with X-rays.

Irradiation with X-rays has provoked variation in many organisms, including fungi; as usual, the results of the experiments have been erratic. Nadson and Philippov‡ irradiated young mycelia of several species of Zygomycetes, with noteworthy effect; disturbances were noted in the amount of the crops of sporangia and zygospores, and in pigmentation. Isolations from treated mycelia of *Mucor genevensis* yielded sectoring colonies, and cultures from the sectors gave variants of greater or less permanency. An interesting variant of *M. genevensis* was first noted as a sector bearing very few zygospores and having globules of reddish yellow oil in the hyphae. Subsequently, a similar variant was obtained from irradiated material of *Zygorhynchus Moelleri*; it formed no zygospores, developed a heavy crop of sporangia, and showed the yellow hyphal inclusions. The connection between disturbances of fertility and the development of pigmentation suggests a parallel with fungi already considered, and further, the induction of reduced fertility and yellow pigmentation in Zygomycetes is of interest, since these characters may appear in ordinary cultures of some Zygomycetes when the general conditions are unfavourable to the fungus. For example, when *Sporodinia grandis* is transferred from its host to potato agar, it often happens that growth falls off after a few transfers; the number of matured reproductive structures then diminishes and both sporangia and zygospores may be replaced by abortive rudiments containing a yellowish pigment and the stock usually dies out. *Phycomyces Blakesleeanus* may show similar but less striking behaviour on unsuitable media. It seems a reasonable conclusion that the likeness between characters following irradiation and characters known to be indicative of unfavourable conditions for growth, shows that irradiation causes damage to the general balance of the fungi concerned.

We owe a very thorough study of the effect of X-rays on fungi to Dickson,§ who worked with both mycelia and spores. He records noteworthy results with *P. Blakesleeanus*, and with several species of *Chaetomium*.

Six hundred subcultures from fifty-eight irradiated plates of *Phycomyces Blakesleeanus* produced seventeen sectoring colonies; eleven

* Bean, W. J. and Brooks, F. T., *New Phytol.* xxxi (1932), 70.
† Dickson, H., *Ann. Bot.* xlvi (1932), 389.
‡ Nadson, G. A. and Philippov, G. S., *C.R. Soc. Biol.*, Paris, xciii (1925), 473; *J. Soc. Bot. Russe*, xiii (1928), 221.
§ Dickson, H., *Ann. Bot.* xlvi (1932), 389; xlvii (1933), 735.

variants were isolated from the sectors. Two, from heavily dosed cultures, did not form sporangia, and gave very few zygospores when mated with the appropriate strain of the parent form—this had not been irradiated. An orange pigment developed in the mycelium. Similar variants appeared in the progeny from less heavily dosed mycelia, so that dosage alone is not the decisive factor. Some variants from moderately dosed cultures were distinguished at first by the abundant and precocious crops of sporangia, but, after three months of culture, these variants were reverting to the parent form.

More productive experiments were made with *Chaetomium cochliodes*. Preliminary observations on more than seven hundred cultures indicated that the stock had no marked tendency to vary in ordinary culture. Young and old mycelium was irradiated, and it was found that variations arose about two and a half times as often from old mycelium as from young mycelium, both having been equally exposed to treatment. Since subcultures from old mycelium, suitably irradiated, gave 92 per cent. variation, there can be little question of the efficacy of X-rays in bringing about change. Treatment of the mycelium of variants led to the appearance of still more variants, some of which seemed to have resumed normal characters. If true reversion did in fact occur, it is difficult to account for these results by supposing that the X-rays had knocked out a gene or destroyed a piece of a chromosome, but this matter cannot be discussed profitably in this place.

In all, Dickson observed some hundreds of variants, and thirty-eight were grown in pure culture; five of these were more or less unstable, the others seemed to be permanent. The changes affected the colour, dimensions, morphology, fertility and staining of the medium; some variants were more fertile than the stock, some less so, and some were sterile, but there was no general relation between increase of sterility and stronger staining of the medium. It appeared that the characters of the parent stocks were not changed in association with one another, except that, when fertility was much reduced, much whitish aerial mycelium might form; this phenomenon has already been noted in fungi after treatment by heat.

Irradiation of suspensions of ascospores did not greatly affect the subsequent germination of the spores, but it had a pronounced effect on survival beyond the earliest stages, for with increase in the length of exposure to the rays there was marked decrease in the number of large mycelia formed. Many of the spores which did establish themselves yielded variants, and the number of variants increased with increase in the time of treatment.

There can be no doubt that X-rays provide a convenient and productive means of inducing variation in fungi. That this is so is well demonstrated by Dickson's investigation of seven species of *Chaet-*

omium; all species gave variants from treated spores, but all did not respond equally strongly. Two of the species were observed to form sectors in ordinary culture, but when the mycelia of these species were irradiated, one species varied seven times as frequently as the other. Dickson had already found that species of *Fusarium*, known to vary greatly in ordinary cultures, were not notably responsive to X-rays; this shows that instability under ordinary culture conditions is no indication that the fungus will react with special readiness to abnormal stimulation.

Dickson tested the effect of ultraviolet light on the mycelium and spores of *Chaetomium cochliodes*. The mycelium seemed to be unaffected, but treated ascospores gave about thirteen variant colonies for every hundred colonies subcultured. Many spores were killed outright. The variants were like those which appeared after the use of X-rays.

From many points of view the fungi are not the most suitable subjects for experiments on induced variation. Their simple organisation seems to be all in favour of reaction, and their rapid growth shortens the time necessary for experiments. On the other hand, the vegetative nuclei are small, and cytological work furnishes more conjectures than facts. Normal sexual processes are commonly absent, so that satisfactory breeding experiments are not possible, and though genetic investigations might be undertaken with some of the Phycomycetes, it is to be remembered that the resting spores of these fungi, formed after a sexual union, do not usually germinate readily. It is therefore fortunate that we can turn to work on induced variation in other organisms, and so supplement the impressions gained from work on fungi.

We may first consider the insects. In the latter years of last century some experiments were made by rearing larvae and pupae of Lepidoptera at high temperatures.* It was shown that by such methods some of the butterflies of Central Europe could be converted into forms comparable with races of the same species characteristic of parts of southern Europe. Heat treatment also yielded specimens with colour patterns suggesting a sort of generalisation of the patterns running through a number of species of the genus; it may be recalled that Dickson noted a tendency towards generalisation during his investigation of seven species of *Chaetomium*. There was some evidence that the induced characters in the butterflies were inheritable, but that side of the work was not pursued.

Much more recently, work on melanism in moths, by Harrison and Garrett,† has provided remarkable evidence on the induction of variation and its transmission to offspring. It has been known for a

* Standfuss, M., *N. Denkschr. schweiz. Ges. Naturwiss.* xxxvi (1899), i, 1; *Ann. Soc. ent. Fr.* lxix (1900), 82.
† Harrison, J. W. H. and Garrett, F. C., *Proc. roy. Soc.* B, xcix (1926), 241.

long time that some moths which are light coloured in rural sur-
roundings remote from towns, are represented in industrial areas by
very dark forms, and the development of these dark forms appears to
have gone on side by side with the growth of industrialism. Analysis
of the smoke begrimed leaves of the food plants of some melanic
moths showed that the dust contained lead and manganese. Light
coloured moths were obtained from rural areas where melanism was
unknown, and after breeding tests had shown that melanism was
apparently absent from the stocks, larvae from these stocks were fed
on contaminated foliage. Ultimately, melanic moths appeared in
the insects so reared, and the melanism was found to act as a Men-
delian recessive. This work provides clear evidence of the induction
of variation and of the transmission of the variation through a normal
sexual process.

Flies belonging to the genus *Drosophila* have been much used in
genetical work, and experiments have led to the induction of variation
in members of this genus. Goldschmidt[*] procured a stock of *D.
melanogaster* from Morgan, taken from a race whose history was well
known. Mating flies were placed in flasks, and removed after eggs
had been laid. Some lots of eggs were placed at $37°$ C. for some hours,
and then kept at $25°$ C., to allow of further development; other lots
were kept at a steady temperature of $25°$ C., a temperature very
favourable to normal development. The results of these experiments
showed many successes and many failures, in this respect agreeing
with the results of high temperature experiments with fungi. The
death rate was high, and of the flies which did survive, many were
quite sterile, or only became fertile after a preliminary period of
sterility; male sterility was specially prevalent. From the progeny of
flies which hatched out, many variants were obtained, including
specimens of some rare variants which had been seen only once before
by any of the numerous workers on this well investigated insect. The
variants included some non-transmissible modifications, and some
which could transmit their characters; at times, flies hatched from
heated eggs or larvae appeared to be normal, but abnormalities were
found in their offspring, an interesting parallel with conditions known
to occur in fungi.

H. J. Muller[†] and his associates have investigated the effects of
X-rays on *Drosophila* very thoroughly, obtaining variants in large
numbers and great variety. Induced sterility was of widespread
occurrence, especially in males. It is well known that *Drosophila*

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[*] Goldschmidt, R., *Biol. Zbl.* XLIX (1929), 437.
[†] Muller, H. J., *Proc. Nat. Acad. Sci.*, Wash., XIV (1928), 714; *Genetics*, XIII (1928),
279; *Hereditas*, XVI (1932), 160; Muller, H. J. and Altenburg, E., *Proc. Soc. Exp.
Biol.*, N.Y., XVII (1919), 10; Muller, H. J. and Mott-Smith, L. M., *Proc. Nat. Acad.
Sci.*, Wash., XVI (1930), 277.

varies spontaneously when grown in tubes with pieces of banana as food, but the suspicion arises that some at least of this supposed spontaneous variation may be induced by the crowded conditions, comparable with the methods used by the Chinese in dealing with goldfish. After treatment with X-rays however, the rate of change is increased enormously. Muller noted that the variants found most frequently in his work were like those which had appeared most frequently in the ordinary cultures of other investigators, this suggesting that some characters or groups of characters are more easily changed than others. One notable variant, distinguished by mottling of the eye, was unstable for that character, again furnishing a parallel with phenomena in some fungal variants.

The use of X-rays and high temperatures together further increased the rate of change, though it was clear that X-rays alone were much more effective than increases of temperature alone; there was however no evidence that the kinds of variants were in any way determined by the agent used to provoke their appearance.

Tobacco plants have proved to be very responsive to X-rays, maybe because the cultivated plant is probably a hybrid, and therefore somewhat unsettled in constitution. A strain of tobacco which has been under observation for twenty-five years, and known to be stable in ordinary cultivation, has been investigated by Goodspeed* and his associates. Unopened flower buds were irradiated for about ten minutes and then allowed to develop; seeds from these buds gave rise to many abnormal plants, the variations affecting the stature of the plants, the shape of the leaves, and the colour, size and shape of the flowers. Some plants raised from seeds of treated flowers appeared to be normal, but, after selfing, variants developed in the progeny of these plants, still another example of delayed action. The plants often showed reduction in fertility, being at times quite sterile. Some plants were a mosaic of normal and variant tissue, and these plants may be compared with a sectoring mycelium. Cytological work showed that irradiation of tobacco plants may be followed by great disturbance in the behaviour of the chromosomes in dividing nuclei, and in the general construction of the nucleus.

Much interesting work on induced variation has been done on *Antirrhinum*. Baur started experiments in Germany as far back as 1908, and, in connection with this work, a stock of *Antirrhinum* has been carried on from year to year by selfing. Close observation of that stock has revealed little evidence of spontaneous variation, and it is of interest that the stock seems to have suffered no serious loss of vigour or diminution of fertility during the long period of inbreeding.

Among many experiments in which this stock has been used by

* Goodspeed, T. H., *Bot. Gaz.* LXXXVII (1929), 563; Goodspeed, T. H. and Olson, A. R., *Proc. Nat. Acad. Sci.*, Wash., XIV (1928), 66.

Baur* and his pupils, some experiments on seeds are of special interest. The seeds were soaked for twenty-four hours and then exposed to the emanations of radium. Little effect was produced unless the seeds were treated for at least forty-five minutes. With longer exposures, the seeds suffered loss of power of germination, and those which did germinate often produced short-lived seedlings with deformed cotyledons. Some plants which survived the seedling stage grew more slowly than normal plants, flowered late, and were specially liable to disease; others were abnormal when young, but seemed to become normal as they matured. A general relation appeared to exist between the duration of the exposure to radium and the extent to which the plants subsequently reacted, but the relation was by no means exact. Sterility was very common in plants grown from treated seeds, and even when abnormalities of morphology disappeared as the plants matured, sterility often persisted. Owing to this sterility, the plants were mostly propagated by vegetative means, giving clones which, commonly, retained the peculiarities of the variant from which the cuttings were taken. Anatomical and cytological investigations revealed a number of irregularities suggesting marked disturbance of ordinary development. The development of the pollen was sometimes so far affected that the process did not get beyond the earliest stages, and there were also indications that, after ovules had been laid down, they could then be replaced by ordinary vegetative tissue. However, some germinable seed was set by the variants, and this, on germination, usually gave normal plants of *Antirrhinum.*

Variants of similar character were obtained from another stock of *Antirrhinum*† after the material had been exposed to X-rays, ultraviolet light, high temperatures, and various chemicals. When young flowers were operated on, treatment was most effective if applied at a time when meiosis was probably in progress. None of the agents seemed to exert a specific effect. It is of note that temperatures of 47° C. soon killed active plant material saturated with water, for still another investigation‡ of *Antirrhinum* showed that a few pollen grains could function after they had been heated for three minutes at 116° C., provided that they were heated in a dry state after a thorough preliminary drying for several days in a desiccator. An even more surprising discovery was, that carefully dried pollen, after being heated at 86° C., for two days, was half as effective in bringing about fertilisation as was normal unheated pollen. As a further illustration of

* Baur, E., *Bibl. genet.*, Lpz., IV (1924); *Z. Bot.* XXIII (1930), 676; *J. R. Hort. Soc.* LVI (1931), 176; Stein, E., *Z. indukt. Abstamm.- u. VererbLehre*, XXIX (1922), 1; XLIII (1927), 1; *Biol. Zbl.*, XLVII (1927), 705; L (1930), 129.
† Stubbe, H., *Z. indukt. Abstamm.- u. VererbLehre*, LVI (1930), 1, 202.
‡ Hiorth, G., *Z. indukt. Abstamm.- u. VererbLehre*, LVI (1930), 39.

the power of carefully dried plant material to resist heat, brief mention may be made of the work of Gain,* on the fruits of *Helianthus annuus*. A few of these retained sufficient vitality after fifteen minutes at 150° C. to begin to germinate, and flowering plants were raised from fruits which had been heated to 120° C.; these plants were unable to set seed.

It is however necessary to return to the experiments with *Antirrhinum*. 434 plants were grown from seed fertilised from strongly heated pollen; they included twenty variants, thirteen of these from pollen which had been heated to 100° C., or to higher temperatures. In contrast with these plants, 2771 plants from seeds fertilised by less strongly heated pollen, included only thirty-two variants. Of the fifty-two variants observed in these experiments, thirty-nine formed little or no pollen, and the plants had malformed anthers, various peculiarities of flower structure, and a tendency to develop very narrow leaves, a common character in abnormal plants of *Antirrhinum*.

One further matter claims our attention, that of the influence of the age of reproductive bodies on the progeny developed from them. Gain (*loc. cit.*) found that similar abnormalities could be obtained in *Helianthus annuus* by strongly heating dry embryos, and by allowing embryos to dry and to age for long periods at ordinary temperatures. Still more recently it has been shown† that old fruits of *Crepis tectorum* may give abnormal plants; in one experiment, twenty-two out of twenty-seven plants from old fruits were abnormal. Cytological investigation of the root tips of these plants revealed many abnormalities in the nuclei, and further, the plants were shown to be chimaeras. The fruits used had been stored in the dry for from five to six years. It was then found that fruits of *C. tectorum*, ripened in the previous season and germinated after being heated for some weeks at about 55° C., gave many deformed plants resembling those grown from old fruits. Fruits of the previous season, after they had been heated in the dry for twenty days at 55° C., usually germinated as well as untreated material of the same age, but the seedlings often failed to get beyond the stage of spreading their cotyledons; of the plants that developed further, most were at first abnormal, but some ultimately assumed a normal appearance. Similar fruits gave a germination of over 70 per cent. after heating for forty days, but after forty-four days the germination was only 44 per cent. Seedlings from the more severely heated material never got beyond the cotyledon stage, and died after about a month. Fruits of the previous season, after treatment with X-rays, behaved much like heated fruits, and like old fruits after some years of dry storage; evidently, the diverse treatments were followed by similar response by the plant.

* Gain, E., *Rev. gén. Bot.* XXXIX (1927), 234, 306.
† Navashin, M. and Shkvarnikov, P., *Nature*, Lond., CXXXII (1933), 482.

Cartledge and Blakeslee* have made comparable observations on a stock of *Datura* that had been under investigation for some years; this stock had a tendency to form aborted pollen grains, and, as that character was easily detected, it was used as a convenient means of estimating the rate at which the stock changed under special treatment. Old seeds, stored in the dry for from four to seven years, yielded many more plants with aborted pollen grains than seeds from one to five years old, similarly stored. There were indications that the tendency to produce abortive pollen was inheritable. The distribution on the plants of the flowers in which pollen abortion was or was not marked, indicated that most of the plants were composed partly of normal and partly of altered tissue; that is, the plants were comparable with a sectoring mycelium; few plants consisted wholly of altered tissue.

In *Helianthus*, in *Crepis* and in *Datura*, it seems that, during storage, or under the influence of special treatment, changes occurred in at least some of the cells of the embryo, and that, at any rate in *Crepis* and *Datura*, these changes resulted in the development of plants of heterogeneous composition; this suggestion however still awaits complete demonstration.

Abnormalities in seedlings grown from aged seed bring us back again to the fungi, for changes in pigmentation of the conidia have been recorded† in species of *Aspergillus* grown from old spores. Unusually blue conidia developed on colonies of *A. versicolor* started from conidia two years old, and conidia nine years old, taken from an apparently normal strain of *A. glaucus*, produced colonies with colourless conidia. The nine-year-old spores did not germinate well, and here, presumably, we have an example of variants derived from moribund spores, a circumstance reminiscent of some of the results obtained in experiments with high temperatures.

The foregoing survey is by no means complete, but it is believed to contain a fair selection of the facts at present available. The selection of facts has been made in order to show the kind of evidence that is available, not to support any special point of view, except the underlying idea that it is possible to induce variation by experimental means. Reference has not been made to the extensive literature on induced variation in bacteria and in many of the lower animals, and no attempt has been made to discuss the large volume of work on the extensive variation shown by some fungi under apparently ordinary conditions of culture. It is however by no means impossible that some of this so-called spontaneous variation may be traced ultimately to

* Cartledge, J. L. and Blakeslee, A. F., *Proc. Nat. Acad. Sci.*, Wash., xx (1934), 103.
† Blochwitz, A., *Ber. dtsch. bot. Ges.* xli (1923), 205.

reactions following on the wounding caused by using pieces of hyphae to start new cultures, and some may be due to the use of media which are really unsuitable to the needs of the fungus. It is usual to assume that media which serve the needs of a particular investigation in providing desired stages in the life-history of a fungus are favourable media for the growth of the fungus but it does not follow that the needs of fungus and investigator necessarily coincide. It is well known that many fungi are stable in culture on such media as potato agar and unstable on synthetic media; the latter, convenient as they are, probably lack some constituent necessary to healthy growth, or contain some substance or combination of substances which, while promoting strong growth, also upset the general balance of the developing organism.

It is natural enough to seek for an explanation of the facts, but it is doubtful if we are yet in a position to begin to suggest one; as the phenomena are far from simple, it is probable that they cannot all be brought under one explanation. Yet, as a conclusion to this provisional survey of a wide field, a few general remarks appear to be necessary; they need not be extensive.

There can be no reasonable doubt that stocks of organisms, known to be stable under ordinary treatment, yield, after certain kinds of experiments, forms which have not been noted before in the stock. Since these forms appear only after experimental treatment, it is not easy to avoid the conclusion that they owe their origin to some effect of the treatment. It has been suggested, and there seems to be no decisive argument to negative the suggestion, that the variants are nothing more than forms of the stock, rarely seen under normal treatment, but selected by the conditions of experiment. It is difficult to accept this view, at any rate for the fungi. Some of the variants differ so conspicuously from normal that they could not be overlooked, did they occur at all frequently in ordinary cultures. The spores of some variants germinate as readily as the ordinary spores, they need no special treatment to cause them to germinate, and the variant colonies do not demand special treatment for their healthy growth. In mixed culture, normals and variants grow side by side and retain their characters, so that they can be distinguished with the utmost ease even in dry cultures which are months or years old. Such variants could hardly escape observation over a period of years if they were normal, though occasional products of a normal strain of fungus. The idea that the variants are selected by the treatment becomes almost absurd when it is recalled how freely variants appeared in *Chaetomium* after treatment with X-rays.

Certain features come out again and again in the results of work on induced variation, and, so far as the peculiarities of their organisation allow, the fungi fit well into the general scheme. Two outstanding

features are, a common but by no means universal reduction in fertility, and a frequent but not invariable weakness in growth; such features suggest that the variants are damaged versions of the normal stocks from which they have sprung. This interpretation is well supported by the abundant evidence that the induction of a variant is often followed by a period of adjustment, a period not always ending in the same way. Sometimes the adjustment cannot be made, and the organism dies, maybe as a sporeling, maybe after it has passed through several transfers: the damage has been so severe that it cannot be repaired. Sometimes adjustment is so complete that the normal form is regained, either in the first culture or after a period of growth: the disturbance has been transitory. Sometimes there is an intermediate condition, and adjustment leads to the establishment of a permanent variant: the damage has caused a shift in the general balance within the organism.

The nature of the change remains obscure. Much time could be spent in speculations about gene changes and alterations in the chromosomes. Such changes may, and probably do occur. It seems highly probable that some nuclear change, and some mixing of nuclei of different qualities must be concerned in a sectoring mycelium, and in induced chimaeras in higher plants. But, until we have more definite evidence it is unwise to attribute everything to nuclear changes; the similar effects which follow heat treatment and age for example, suggest that a general derangement of the physiological balance of the cell may well be responsible. The likeness that seems to exist between the effects on cells of violent external treatment and of the slow changes which must proceed in resting spores and seeds, is perhaps the most interesting feature of work on induced variation; the violent external agents may well hasten the normal changes of a degenerative nature which presumably assist in bringing about the death of a spore or seed unable for some reason to germinate. We have at least a glimpse of a possibility that some new forms may arise from aged material and establish themselves. If this be so, the evolutionary process may depend in part on the running down of the biological machine.

COOKE'S *ILLUSTRATIONS OF BRITISH FUNGI*

THE eight volumes of Cooke's *Illustrations of British Fungi* are much prized, but referred to with increasing doubt as a wider knowledge of agaric species is obtained. The fact is that a large proportion of the plates are wrongly or doubtfully named. For the most part the figures are well done; there are of course some poor figures, but the whole forms a very valuable series, perhaps the finest set of illustrations of agarics in existence. Many modern reproductions are superior, but are scattered in various publications not easily acquired.

In the *Transactions* of this Society there have been two lists of criticisms of the Cooke plates. C. B. Plowright (*Trans. Brit. mycol. Soc.* 1 (1898), 39–40) made a few comments in his presidential address, but suggested only a few changes in the names given by Cooke. Émile Boudier (II (1906), 150–7) made some rectifications and observations which were very illuminating. Cooke (III (1907), 26–9) replied, agreeing to some of the determinations but vigorously disputing others. Since then there have been numerous citations that sometimes have referred to species other than what Cooke named them, but there has been no paper covering all the plates.

By a fortunate chance my friend, M. Joachim, a past President of the Société Mycologique de France, showed me the copy of a manuscript which had been written by Lucien Quélet. It bore the title "Annotations d'après le Dr Quélet des planches de l'ouvrage: Handbook of British Fungi by M. C. Cooke, second and revised edition. London 1883". The title is erroneous, as the annotations were not of Cooke's Handbook, but of the *Illustrations of British Fungi* (1881–91). The manuscript contains Quélet's views of all the plates. Where he makes no comment, it is to be presumed that he agrees with the name printed on the plate.

The manuscript appeared to be of so much interest that I asked M. Joachim for permission to have it reproduced in these *Transactions*.

It then occurred to me that the work could be made much more useful if supplemented with a review of Cooke's *Illustrations* by modern mycologists well qualified to undertake this task, and I therefore referred to the two eminent authorities, Prof. Dr René Maire and Mr Carleton Rea. They both very kindly agreed to annotate the plates, and the result is here given in tabular form. In frequent cases there will be found a conflict of opinion. This was inevitable. Even with the living fungus, eminent mycologists do not always agree. How much more must this occur with an illustration which may be an imperfect representation of the original? The true identity of many of the agarics figured by Cooke can never be known with certainty.

Dr Maire, in his manuscript, used many of the new generic names which are now generally adopted by French mycologists. These, however, are not printed, as the purpose of the annotations is sufficiently served by using the specific epithets only, except where clearness requires the genus to be shown.

In the columns under both Maire and Rea, a dash does not indicate agreement as in the Quélet column, but means that no opinion is ventured.

The annotations could have been made more complete by including the many citations from monographs, etc., that have appeared in recent years. Doubtless this would have added interest and would have revealed further differences of opinion. I doubt, however, whether it would have added to the practical value of the paper. All will continue to have their own views about some of the plates, but the new light that is now thrown upon Cooke's *Illustrations of British Fungi* will be welcomed by students of the agarics everywhere.

The species have been listed in the rotation of the bound volumes as finally issued. This does not correspond with the numbering on the plates. There are many volumes scattered about the world which have been bound differently, so an index to the plate numbers has been added which will give further value to the present paper.

A. A. PEARSON.

COOKE'S *ILLUSTRATIONS OF*
BRITISH FUNGI

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
1	1	*Agaricus* (*Amanita*) *virosus*			*solitaria*
2	2	—	—	*phalloides*	ou *junquillea*
3	3	—	—	*vernus*	ou *citrina* var. *albata*
4	4	—	—	*mappa*	—
5	117	—	—	*muscarius*	—
6	6	—	—	*pantherinus*	?
7	7	—	—	*excelsus*	*virescens* (excepté le bulbe)
8	8	—	—	*strobiliformis*	non! inconnu—*rubens* (?)
9	277	—	—	*strobiliformis*	ou *solitaria*
10	9	—	—	*rubescens*	—
11	69	—	—	*spissus*	?
12	70	—	—	*nitidus*	*aspera* var. *pallescens*
13	10	—	—	*asper*	?
14	34	—	—	*magnificus*	—
15	11	—	—	*megalodactylus*	*Lepiota guttata* (?)
16	12	—	—	*vaginatus*	
17	13	—	—	*strangulatus*	malé
18	35	—	—	*adnatus*	(?) *junquillea* vetustior ou *aspera* pallescens
19	21	—	(*Lepiota*)	*procerus*	trop petit...*mastoidea*
20	22	—	—	*rhacodes*	—
21	23	—	—	*excoriatus*	—
22	28	—	—	*gracilentus*	—
23	24	—	—	*mastoideus*	représente mieux *cristata*
24	14	—	—	*acutesquamosus*	—
25	25	—	—	*Badhami*	—
26	26	—	—	*meleagris*	—
27	37	—	—	*biornatus*	—
28	27	—	—	*hispidus*	non !
29	38	—	—	*clypeolarius*	?
30	39	—	—	*metulaesporus*	*clypeolaria*, gracilis avec état maladif des lamelles
31	29	—	—	*cristatus*	?
32	40	—	—	*ermineus*	—
33	36	—	—	*Vittadini*	—
34	41	—	—	*holosericeus*	ou plutôt *guttata* (?)
35	15	—	—	*naucinus*	—
36	5	—	—	*cepaestipes*	*lutea* et *cepaestipes*
37	42	—	—	*carcharias*	—
38	43	—	—	*cinnabarinus*	—
39	18	—	—	*granulosus*	—
40	213	—	—	*granulosus* var. *rufescens*	—
		—	—	*amianthinus*	—

MAIRE	REA	No. of bound volume	No. printed on Plate
virosa, mais très robuste	typical *verna* (syn. *virosa*)	1	1
citrina, mais à marge de la volve plus développée que d'habitude, lamellules inexactes	*phalloides*, with typical free-lobed volva	2	2
citrina var. *alba*	*mappa* var. *alba* Gill.	3	3
citrina var. *alba*	*mappa* (syn. *citrina*)	4	4
muscaria	*muscaria*	5	117
plutôt forme de *spissa*	*pantherina*. It has the striate margin and concentric rings to apex of volva	6	6
forme de *spissa*, teinte trop verte	*excelsa*	7	7
peut-être *A. Emilii* Riel	—	8	8
solitaria	*strobiliformis* typical	9	277
rubescens	*rubescens*	10	9
spissa mais atypique. La figure du haut rappelle plutôt *aspera*	*spissa* poor	11	69
(?) mauvaise figure de *echinocephala*	—	12	70
aspera (forme à verrues grisâtres)	—	13	10
anomalie de *rubescens*	*rubescens* poor	14	34
lenticularis var. *eguttata*	*lenticularis* poor	15	11
vaginata	*vaginata*	16	12
inaurata	*strangulata* (syn. *inaurata*)	17	13
Amanita gemmata Fr. (=*junquillea* Q.)	*adnata* (syn. *junquillea* and *gemmata*)	18	35
procera, petite forme	*procera*	19	21
rhacodes	*rhacodes*	20	22
excoriata	*excoriata*	21	23
gracilenta?	not *gracilenta*, does not show minute scales on stem	22	28
trop petit et trop mince, peut-être *L. cepaestipes* var. *nigricans* Bagl.	not *mastoidea*, does not show excoriated margin or scales on stem	23	24
acutesquamosa	*acutesquamosa*, large form	24	14
Badhami (spores, données d'après Massee, trop petites)	*Badhami* typical	25	25
meleagris	*meleagris*	26	26
très voisin d'un *Lepiota* fréquent à Alger, mais dont la chair ne rougit pas	*biornatus*	27	37
forme de *clypeolaria*	*clypeolaria* type	28	27
Do.	*clypeolariodes* Rea	29	38
Do.	*clypeolaria*	30	39
cristata probablement	*cristata*	31	29
erminea	*erminea*	32	40
Vittadinii	*Vittadinii*, but should give gills finally greenish	33	36
?	*holosericea*	34	41
naucina	*naucina*, hot bed form	35	15
lutea	*lutea*	36	5
cepaestipes	*cepaestipes*		
carcharias	*carcharias*	37	42
cinnabarina	*cinnabarina*	38	43
granulosa	*granulosa*	39	18
carcharias	*carcharias*		
?	*granulosa* var. *rufescens*	40	213
amianthina	*amianthina*		

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
41	30	*Agaricus (Lepiota)*		*polystictus*	Armill. rufa, gracilis ? Arm. luteo-vireus, gracilis ?
42	85	--	---	*sistratus*	---
		---	---	*mesomorphus*	
43	19	---	---	*seminudus*	et var. *lilacina* Quél.
		---	---	*Bucknalli*	
44	44	---	---	*medullatus*	copié
45	118	---	---	*gliodermus*	
		---	---	*delicatus*	?
46	17	---	---	*lenticularis*	
47	132	---	---	*Georginae*	haematosperma, forme très grêle
48	20	---	(*Armillaria*)	*bulbiger*	---
49	245	---	---	*focalis*	---
50	31	---	---	--- var. *Goliath*	---
51	33	---	---	*aurantius*	?
52	86	---	---	*robustus* var. *minor*	subannulata Batsch
53	71	---	---	*ramentaceus*	---
54	45	---	---	*haematites*	carcharias, forme malade
55	46	---	---	*constrictus*	holosericea
56	32	---	---	*melleus*	---
57	47	---	---	*subcavus*	cepaestipes ou *serena*
58	16	---	---	*mucidus*	---
59	72	---	(*Tricholoma*)	*equestris*	---
60	53	---	---	*sejunctus*	malè
61	54	---	---	*portentosus*	Coll. grammocephala Bull.
62	73	---	---	*fucatus*	?
63	74	---	---	*quinquepartitus*	---
64	55	---	---	*resplendens*	le violet rappelle plutôt columbetta
65	87	---	---	*spermaticus*	columbetta, vetusta
66	75	---	---	*colossus*	---
67	76	---	---	*acerbus*	malè
68	56	---	---	*nictitans*	fulvum
69	57	---	---	*fulvellus*	fulvum ou *ustale* grêle
70	58	---	---	*flavo-brunneus*	malè
71	197	---	---	*albo-brunneus*	---
72	88	---	---	*ustalis*	---
73	198	---	---	*stans*	striatum
74	89	---	---	*rutilans*	---
75	214	---	---	*luridus*	?
76	59	---	---	*guttatus*	rappelle Coll. maculata
77	48	---	---	*columbetta*	---
78	215	---	---	*scalpturatus*	luridum
79	199	---	---	*imbricatus*	---
80	60	---	---	*imbricatus*	---
81	61	---	---	*immundus*	---
82	49	---	---	*murinaceus*	---
83	50	---	---	*terreus*	hordum
84	165	---	---	---var. *argyraceus*	---
85	51	---	---	*atrosquamus*	orirubens ou *argyraceum*
86	90	---	---	*ori-rubens*	malè

Maire	Rea	No. of bound volume	No. printed on Plate
?	*polysticta*	41	30
—	*sistrata* ?	42	85
seminuda *Bucknallii*, mauvaise figure	*seminuda* I doubt *Bucknallii* though I know it well looks like Fries Icones figure	43 44	19 44
glioderma	*glioderma*	45	118
lenticularis *Georginae*	*lenticularis* *Georginae*	46 47	17 132
bulbiger	*bulbigera*	48	20
—	—	49	245
—	—	50	31
robusta	*robusta*	51	33
—	—	52	86
ramentacea	*ramentacea*	53	71
haematites	like the original painting of *haematites*	54	45
constricta	*constricta* typical	55	46
mellea	*mellea*	56	32
Lepiota Brebissoni Godey ou *Magnusiana* P. Henn., Maire	—	57	47
mucida	*mucida*	58	16
trop pâle	*equestre*	59	72
Tr. sejunctum, mauvaise figure	possibly *sejunctum* but not typical	60	53
Coll. platyphylla	*platyphylla*	61	54
?	—	62	73
?	—	63	74
?	*resplendens*, the pileus is viscid	64	55
?	*spermaticum*, sp. verrucose	65	87
Tr. colossus	—	66	75
suffocatum	*acerbum*, but too deep in colour	67	76
flavobrunneum	—	68	56
?	—	69	57
pessundatum, mauvaise figure	possibly *pessundatum*	70	58
albobrunneum, mauvaise figure	*albobrunneum* typical	71	197
ustale	*ustale*	72	88
albobrunneum? malé	*stans*	73	198
rutilans	*rutilans*	74	89
?	*luridum* poor	75	214
orirubens? ou forme voisine	*guttatum* (Schaeff.) Rea	76	59
columbetta	*columbetta*	77	48
? *atrosquamosum*, mauvaise figure	certainly not *sculpturatum*	78	215
imbricatum	*imbricatum* poor	79	199
vaccinum	*vaccinum* typical	80	60
T. immundum = *T. fumosum* Pers. non Fr.	*Collybia fumosa* Pers.	81	61
murinaceum Fr. non Quél., mauvaise figure	*murinaceum* typical	82	49
?	a form of *terreum*	83	50
scalpturatum = *argyraceum*	*argyraceum* typical	84	165
atrosquamosum?	*terreum* var. *atrosquamosum*	85	51
orirubens	*orirubens* (? diseased form of *terreum*)	86	90

No. of bound volume	No. printed on Plate	Cooke		Quélet
87	278	*Agaricus (Tricholoma) macrorhizus*		
88	91	—	*saponaceus*	*malè*
89	216	—	id. var. *stipite-squamuloso*	
90	166	—	*cartilagineus*	*triste*
91	52	—	*atrocinereus*	
		—	*cuneifolius*	
92	261	—	*cuneifolius* var. *cinereo-rimosus*	? forme de *Russula lilacea*
93	92	—	*crassifolius*	*Georgii*
94	93	—	*tumidus*	*hordum* ?
95	167	—	*virgatus*	
96	62	—	*sulphureus*	
97	181	—	*bufonius*	
98	94	—	*lascivus*	*album*, gracile ?
99	217	—	id. var. *robustus*	*Omphalia gilva*
100	77	—	*inamaenus*	copié de Fries
101	95	—	*ionides*	*malè*
		—	*cerinus*	*Marasmius Oreades*
102	96	—	*carneus* }	
		—	*coelatus* }	mal copiés
103	63	—	*gambosus*	*Clitocybe geotropa*
104	262	—	*amethystinus*	non! *luridum* ?
105	229	—	*albellus*	*Georgii*, *malè*
106	64	—	*tigrinus*	non! copié de Fries
107	168	—	*Schumacheri*	forme de *nebularis*
108	279	—	*patulus*	
109	218	—	*arcuatus*	
		—	*oreinus*	? *malè*
110	65	—	*albus*	non! *Cort. sebaceus* ?
111	78	—	*leucocephalus*	
112	169	—	*militaris*	quelque chose de *acerbum*
113	66	—	*personatus*	*malè*
114	67	—	*nudus*	*malè* ?
115	133	—	id. var. *major*	*malè*
116	170	—	*cinerascens*	*malè*
117	97	—	*panaeolus*	
118	98	—	*grammopodius*	
119	119	—	*melaleucus* et var. *porphyroleucus*	
120	68	—	*brevipes*	?
121	99	—	*humilis*	*humile* ?
122	263	—	*humilis*	*sordidum* *malè*
123	171	—	*exscissus*	
124	219	—	*subpulverulentus*	
125	100	—	*sordidus*	*malè*
126	120	—	*paedidus*	
		—	*lixivius*	ou *melaleucum*
127	172	—	*putidus*	*malè*
128	79	— (Clitocybe)	*nebularis*	
129	80	—	*clavipes*	
130	246	—	*inornatus*	
		—	*hirnaeolus*	? *leucophylla*
131	264	—	*cyanophaeus*	forme de *sordidum*
132	134	—	*amarus*	
		—	*socialis*	*flaccida*

Maire	Rea	No. of bound volume	No. printed on Plate
?	—	87	278
saponaceum, mauvaise figure	*saponaceum*	88	91
saponaceum var.	id. var. *stipite-squamuloso*	89	216
terreum	a form of *terreum*	90	166
atrocinereum	*atrocinereum*	91	52
cuneifolium	*cuneifolium*		
cuneifolium forma	var. *cinereo-rimosum*	92	261
Georgii forma ?	not *crassifolium* of my work	93	92
?	—	94	93
virgatum	*virgatum*	95	167
sulphureum	*sulphureum*	96	62
id. var. *bufonium*	*bufonium*	97	181
? trop grêle	—	98	94
Clitocybe Alexandri Fr.= *C. gilva* Quél. non Fr.	—	99	217
inamaenum	*inamaenum*	100	77
ionides	*ionides*	101	95
?	not *cerinus*		
carneum	*carneum* typical	102	96
caelatum	*caelatum* typical		
?	*gambosum*	103	63
?	—	104	262
Georgii, trop jaune	—	105	229
inspiré de Fries	—	106	64
Clitocybe nebularis	—	107	168
?	not *patulum*	108	279
forme de *brevipes*	*brevipes*	109	218
graminicola (Velen.)	—		
beaucoup trop jaune. *Clitocybe* ?	*album*, extreme form	110	65
—	*leucocephalum*	111	78
—	*militare*	112	169
saevum (= *personatum* var. *anserinum* Fr.)	*personatum* type	113	66
do.	*saevum*	114	67
do.	*personatum*	115	133
?	*cinerascens* poor	116	170
Panaeolus	*panaeolus*	117	97
grammopodium	*turritum*	118	98
melaleucum	*melaleucum*	119	119
	id. var. *porphyroleucum*		
brevipes	*brevipes*	120	68
melaleucum var. *phaeopodium*	—	121	99
sordidum, mais lamelles trop pâles	*sordidum*		
? ?	*humile*	122	263
melaleucum var. *excissum*, pâle	*melaleucum*		
melaleucum var. *excissum* ?	*excissum* poor	123	171
—	*subpulverulentum*	124	219
sordidum, mauvaise figure	*sordidum*	125	100
—	—	126	120
—	—		
?	—	127	172
nebularis	*nebularis*	128	79
clavipes	*clavipes* poor	129	80
inornata	*inornata*	130	246
? ?	—		
Panus torulosus jeune ?	—	131	264
amara, trop jaune	*amara*	132	134
?	—		

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
133	265	*Agaricus (Clitocybe) venustissimus*			copiés
134	101	—	—	odorus	
135	102	—	—	trogii	forme de *viridis* décoloré
136	200	—	—	rivulosus	ventosa
		—	—	id. var. neptuneus	absolument faux ! ? *pyxidata*
137	121	—	—	cerussatus	
138	122	—	—	id. var *difformis*	
139	81	—	—	phyllophilus	
140	103	—	—	pithyophilus	
		—	—	tornatus	
141	82	—	—	candicans	phyllophila
142	104	—	—	dealbatus	cerussata
143	173	—	—	id. var. minor	
144	174	—	—	gallinaceus	phyllophila
145	182	—	—	aggregatus	
146	280	—	—	elixus	gilva Pers. ?
147	175	—	—	fumosus	
148	105	—	—	tumulosus	
149	176	—	—	opacus	?
150	106	—	—	giganteus	
151	135	—	—	maximus	geotropa
152	107	—	—	infundibuliformis	
153	281	—	—	incilis	?
154	83	—	—	parilis	trop jaune
155	177	—	—	geotropus	
156	108	—	—	id. var. *subinvolutus*	
157	136	—	—	subinvolutus	geotropa
158	109	—	—	gilvus	
159	84	—	—	splendens	
160	123	—	—	flaccidus	
				flaccidus	
161	137	—	—	lobatus	
162	110	—	—	senilis	
163	111	—	—	catinus	
164	112	—	—	tuba	
165	138	—	—	ericetorum	
166	113	—	—	cyathiformis	
167	220	—	—	expallens	cyathiformis
168	230	—	—	obbatus	expallens ?
169	231	—	—	pruinosus	squamulosa
170	114	—	—	brumalis	
171	115	—	—	metachrous	
172	116	—	—	ditopus	
173	232	—	—	diatretus	?
174	124	—	—	fragrans	
175	125	—	—	angustissimus	
176	233	—	—	obsoletus	dealbata
177	126	—	—	ectypus	
178	183	—	—	bellus	
179	139	—	—	laccatus	Collybia
180	127	—	—	Sadleri	
181	140	—	(Collybia)	radicatus	
182	201	—	—	longipes	
183	128	—	—	platyphyllus	

MAIRE	REA	No. of bound volume	No. printed on Plate
Pleurotus olearius ?	—	133	265
venustissima	*venustissima*		
odora, mauvaise figure	*odora* poor	134	101
odora var. *Trogii*	*viridis*	135	102
rivulosa ?, mauvaise figure	not *rivulosa*	136	200
Omphalia pyxidata			
cerussata	*cerussata*	137	121
—	—	138	122
phyllophila	*phyllophila*	139	81
gallinacea	—	140	103
tornata	*tornata*		
gallinacea ?	*phyllophila*	141	82
ressemble un peu à *connata*	*cerussata* not typical	142	104
?	*dealbata* var. *minor*	143	173
gallinacea	*gallinacea*	144	174
aggregata	*aggregata*	145	182
inornata	*inornata*	146	280
Col. fumosa Fr. non Quél. nec Bres.	*Tr. cinerascens*	147	175
tumulosa	*tumulosa*	148	105
		149	176
gigantea	*gigantea*	150	106
geotropa forma *maxima*	*maxima*	151	135
infundibuliformis	*infundibuliformis*	152	107
—	*incilis* poor, margin should be crenate	153	281
parilis	*parilis* typical		
geotropa	*geotropa*	154	83
geotropa, mais spores inexactes	*subinvoluta*	155	177
geotropa	—	156	108
infundibuliformis forma *gibba* Fr. Mon. p. 119	*infundibuliformis*	157	136
splendens	*splendens* small form	158	109
inversa	*inversa*	159	84
inversa (*C. flaccida*, insuffisamment distinct d'*inversa*)	*flaccida*	160	123
inversa	*lobata*	161	137
?	*viridis*	162	110
catinus, trop blanc	*catinus*	163	111
tuba	*tuba*	164	112
ericetorum ? ou *Hygrophorus niveus* ?	*ericetorum*	165	138
cyathiformis	*cyathiformis*, but does not show reticulate stem	166	113
cyathiformis, forme grêle ?	*expallens*	167	220
?	—	168	230
?	*cyathiformis* var., stem is right	169	231
brumalis	*brumalis*, but does not show the finally yellowish gill	170	114
metachroa	*metachroa* small form	171	115
ditopa	*ditopa*	172	116
diatreta	*diatreta*	173	232
fragrans	*fragrans*	174	124
angustissima	*angustissima*	175	125
?	—	176	233
cyathiformis	*cyathiformis*	177	126
—		178	183
Laccaria laccata et var. *amethystina*	*laccata* and var. *amethystina*	179	139
fasciculare, forme stérile	*fasciculare*	180	127
radicata	*radicata*	181	140
longipes	*longipes*	182	201
platyphylla	*platyphylla*	183	128

No. of bound volume	No. printed on Plate	COOKE		QUÉLET
184	292	*Agaricus (Collybia)*	*semitalis*	
185	141		*fusipes*	
186	142		*maculatus*	
187	221		var. *immaculatus*	
188	282		*distortus*	
189	143		*butyraceus*	
190	202		*xylophilus*	
191	184		*velutipes*	
			laxipes	
192	129		*mimicus*	*dryophila*
193	149		*vertirugis*	
			stipitarius	
194	150		*hariolorum*	
			confluens	
195	283		*ingratus*	
196	130		*conigenus*	
197	144		*tuberosus*	
			cirrhatus	
198	205		*collinus*	malé
199	145		*ventricosus*	
			Stevensoni	
200	266		*psathyroïdes*	forme de *Mycena nivea*
201	203		*xanthopus*	*dryophila*
202	146		*nitellinus*	*extuberans*
203	151		*succineus*	non ?
			nummularius	*aquosa*
204	152		*esculentus*	
			tenacellus	
205	267		*acervatus*	malé
206	204		*dryophilus*	
207	234		*aquosus*	? *dryophila*
208	268		*exsculptus*	
			macilentus	*dryophila*
209	147		*clavus*	*Mycena acicularis*
			ocellatus	*Mycena flavo-alba*
			muscigenus	*Mycena lactea*
210	153		*rancidus*	
			coracinus	
211	154		*inolens*	
			plexipes	*rancida*
212	155		*atratus*	
			ambustus	
213	269		*laceratus*	*Hygrophorus distortus*
214	270		*protractus*	
			tesquorum	
215	247		*tylicolor*	
			clusilis	
216	156	(*Mycena*)	*pelianthinus*	malé
			balaninus	
217	284		*elegans*	
218	131		*rubro-marginatus*	
			strobilinus	*coccinea*
			— var. *coccineus*	
219	157		*rosellus*	
220	158		*purus*	
			pseudopurus	*pura*
			zephirus	

Maire	Rea	No. of bound volume	No. printed on Plate
semitalis	*semitalis*	184	292
fusipes	*fusipes*	185	141
maculata	*maculata*	186	142
?	*maculata* var. *immaculata*	187	221
distorta	*distorta*	188	282
butyracea	*butyracea*	189	143
?	—	190	202
velutipes	*velutipes*	191	184
?	*laxipes*		
—	*mimica*	192	129
Marasmius undatus	*undatus*	193	149
Crinipellis stipitarius	*stipitarius*		
—	both *hariolorum*	194	150
confluens	—		
acervata vieux	*acervata*	195	283
conigena	*conigena*	196	130
tuberosa	both *tuberosa*	197	144
cirrhata Cke. non Schum.= *C. cirrhata* var. *Cookei* Bres.	—		
—	—	198	205
radicata forma	—	199	145
—	—		
Mycena sp.	—	200	266
dryophila	*xanthopus*	201	203
extuberans ? certe non *nitellina*	*extuberans*	202	146
?	*succinea* rather too dark	203	151
dryophila forma *aquosa*	*nummularius*		
clavus (sensu Quélet)	*esculentus*	204	152
clavus (sensu Quélet)	*esculentus*		
acervata	*acervata*	205	267
dryophila	*dryophila*	206	204
dryophila forma *aquosa*	*dryophila* var. *aquosa*	207	234
dryophila var. *funicularis*	—	208	268
dryophila var. *funicularis*	*dryophila* var. *funicularis*		
Mycena acicula	*Mycena clavus*	209	147
Collybia cirrhata	*ocellata*		
Mycena lactea	*muscigena*		
rancida	*rancida*	210	153
coracina	*coracina*		
inolens ?	*inolens*	211	154
rancida ? ? (lui ressemble mais dit inodore)	*plexipes*		
atrata	*atrata*	212	155
ambusta	*ambusta*		
lacerata ?	not *lacerata*	213	269
—	*protracta*	214	270
—	*tesquorum*		
—	*tylicolor*, the stem is white pruinose	215	247
clusilis	*clusilis* typical		
pelianthina ?	*pelianthina*	216	156
Marasmius cohaerens	*balanina* ? = *atro-marginata*		
Langei ?	?	217	284
rubromarginata	*rubromarginata*		
strobilina	*strobilina*	218	131
coccinea	*coccinea*		
rosella	*rosella*		
pura	*pura*	219	157
pura forma	*pura*	220	158
zephirus	*zephirus*		

No. of bound volume	No. printed on Plate	COOKE		QUÉLET
221	185	Agaricus (Mycena)	Adonis	floridula
		—	lineatus	
222	159	—	luteo-albus	
		—	flavo-albus	
		—	lacteus	
223	235	—	proliferus	trop jaune
224	148	—	excisus	
225	186	—	psammicola	filopes ou debilis ?
		—	rugosus	ammoniaca
226	206	—	sudorus	galericulata f. alba
227	222	—	galericulatus	
		—	— terrestrial var.	
228	223	—	var. calopus	
		—	polygrammus	
229	224	—	parabolicus	
		—	tintinabulum	
230	285	—	dissiliens	
		—	plicosus	
231	236	—	pauperculus	cyanorhiza ?
		—	atro-cyaneus	
232	237	—	pullatus	galopus
233	187	—	leptocephalus	
		—	alcalinus	ammoniaca
234	225	—	alcalinus	
235	238	—	ammoniacus	
		—	metatus	
236	188	—	aetites	malè, trop jaune
		—	stanneus	collariata
237	160	—	vitreus	? malè
		—	tenuis	
238	161	—	filopes	
		—	Iris	
239	286	—	amictus	
240	189	—	debilis	luteoalba
		—	vitilis	
		—	collariatus	non. lineata ?
241	190	—	speireus	malè, pas jaune
		—	tenellus	Omphalia stellata ?
		—	acicula	malè, pas rosé
242	162	—	haematopus	
		—	cruentus	
243	163	—	sanguinolentus	
		—	crocatus	
244	207	—	chelidonius	
		—	galopus	
245	208	—	epipterygius	
		—	clavicularis	
246	191	—	pelliculosus	
		—	vulgaris	rorida
247	248	—	citrinellus	
		—	plicato-crenatus	
		—	roridus	
248	249	—	stylobates	
		—	tenerrimus	
		—	electicus	
249	192	—	sacchariferus	
		—	discopus	
		—	pterigenus	

MAIRE	REA	No. of bound volume	No. printed on Plate
Adonis	*Adonis*	221	185
lineata	*lineata*		
flavo-alba ?	*luteo-alba*	222	159
flavo-alba ?	*flavo-alba*		
lactea var. *pitya*	*lactea*		
—	*prolifera*	223	235
galericulata vieux?	*Berkeleyi*, but unknown to me	224	148
debilis ?	—	225	186
rugosa	*rugosa*		
galericulata forma *alba*	*sudora* (viscid on pileus)	226	206
galericulata	*galericulata*	227	222
?	*galericulata*		
inclinata (sensu Quélet)	*galericulata* var. *calopus*	228	223
polygramma	*polygramma*		
—		229	224
—	*dissiliens*	230	285
—	*plicosa*		
?	—	231	236
atro-cyanea	*atrocyanea*		
—	*pullata*	232	237
alcalina?	—	233	187
ammoniaca	—		
inclinata en haut	*inclinata* typical	234	225
inclinata en bas ou forme de *galericulata*	*alcalina*		
ammoniaca ?	*ammoniaca*	235	238
metata	*metata*		
certe non *aetites*	not *aetites*	236	188
?	—		
—	—	237	160
filipes ?	*filopes*	238	161
Iris	*Iris*		
amicta ?	*amicta*, quite distinct from *Iris*	239	286
luteo-alba	—	240	189
vitilis ?	*vitilis*		
?	—		
Omphalia tenuistipes ?	—	241	190
Omphalia mauretanica Maire ?	*tenella*		
acicula, mauvaise figure	*acicula*		
haematopoda	*haematopus* (stem should be darker)	242	162
cruenta	*cruenta*		
sanguinolenta, couleurs trop vives	*sanguinolenta*	243	163
crocata	—		
—	—	244	207
galopoda	*galopus*		
epipterygia	*epipterygia*	245	208
—	—		
?	*pelliculosa* typical	246	191
rorida	*vulgaris*		
—		247	248
—	*plicato-crenata*		
rorida	*rorida*		
stylobates	*stylobates*	248	249
tenerrima	*tenerrima*		
Omphalia electica	—		
—		249	192
—	*discopus* typical		
	pterygena typical		

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
250	164	Agaricus	(Mycena)	corticola	
		———	———	hiemalis	
251	193	———	———	setosus	
		———	———	capillaris	
		———	———	juncicola	
252	239	———	(Omphalia)	hydrogrammus	
253	287	———	———	maurus	non verdâtre
		———	———	offuciatus	
254	194	———	———	Postii	
		———	———	pyxidatus	
255	288	———	———	leucophyllus	
		———	———	striaepileus	
256	240	———	———	telmatiaeus	
257	289	———	———	sphagnicola	
		———	———	philonotis	leucophylla
258	209	———	———	oniscus	
		———	———	caespitosus	umbellifera var. flava
259	250	———	———	demissus	
		———	———	hepaticus	
		———	———	muralis	pyxidata, malé
260	271	———	———	umbelliferus	
261	272	———	———	buccinalis	
		———	———	retostus	cendré
		———	———	abhorrens	
262	241	———	———	pseudo-androsaceus	
		———	———	griseo-pallidus	
		———	———	stellatus	
263	273	———	———	campanella	
		———	———	—— var. badipus	
		———	———	pictus	
264	210	———	———	camptophyllus	
		———	———	griseus	
265	274	———	———	umbratilis	
		———	———	fibula	
266	251	———	———	directus	
		———	———	belliae	rorida (vetustior)
267	252	———	———	gracillimus	stellata ou integrella
		———	———	bullula	M. Micheliana
		———	———	integrellus	
268	290	———	(Pleurotus)	corticatus	dryinus
269	226	———	———	dryinus	
270	253	———	———	spongiosus	ostreatus var. columbinus
271	227	———	———	ulmarius	
272	254	———	———	tessulatus	
273	255	———	———	subpalmatus	
274	256	———	———	craspedius	ulmarius
275	178	———	———	fimbriatus	palmatus
		———	———	Ruthae	
276	257	———	———	lignatilis	
		———	———	circinatus	
277	179	———	———	pantoleucus	conchatus
278	275	———	———	pantoleucus	
		———	———	mutilus	scyphoides (major)
279	195	———	———	ostreatus	
280	196	———	———	—— var. euosmus	
281	180	———	———	revolutus	
282	228	———	———	salignus	ostreatus (genuinus)
283	291	———	———	acerinus	dryinus
284	258	———	———	petaloides	
		———	———	serotinus	malé

MAIRE	REA	No. of bound volume	No. printed on Plate
corticola	*corticola*	250	164
hiemalis ?	*hiemalis*		
———	*setosa*	251	193
capillaris	*capillaris*		
———	———		
———	*hydrogramma*	252	239
maura	*maura*	253	287
?	———		
Postii	*Postii*	254	194
pyxidata	*pyxidata*		
?	———	255	288
———	———	256	240
———	*sphagnicola*	257	289
———	———		
onisca	*onisca*	258	209
umbellifera var. *flava*	*umbellifera* var. *flava*		
———	———	259	250
———	*hepatica*		
———	*muralis*		
umbellifera	*umbellifera*	260	271
———	———	261	272
———	*retosta*		
———	*abhorrens*		
———	———	262	241
griseo-pallida	———		
?	*stellata*, but should be white		
campanella	*campanella*	263	273
Marasmius fulvo-bulbillosus	*cauticinalis*		
picta ?	*picta*		
———	*camptophylla*	264	210
grisea	*grisea*		
———	*umbratilis*	265	274
fibula et var. *Swartzii*	*fibula* et var. *Swartzii*		
———	*pseudo-directa*	266	251
Mycena rorida ?	———		
integrella ?	*gracillima*	267	252
?	*bullula*		
cuspidata Quél. ?	———		
corticatus = *dryinus*	*corticatus*	268	290
corticatus = *dryinus*	*dryinus*	269	226
ostreatus var. *columbinus*	*columbinus*	270	253
ulmarius	*ulmarius*	271	227
	———	272	254
palmatus	*palmatus*	273	255
ulmarius	not *craspedius*	274	256
lignatilis ?	*fimbriatus*	275	178
———	*Ruthae*		
lignatilis	*lignatilis*	276	257
———	*circinatus*		
Panus torulosus ?	*palmatus*	277	179
———	spores wrong for *pantoleucus*	278	275
mutilus (forme de *Omphalia scyphoides*)	*mutilus*		
cornucopiae	*sapidus* (spores lilac in mass)	279	195
ostreatus var.	*sapidus*	280	196
Panus torulosus ?	*revolutus* var. *anglicus* Massee	281	180
ostreatus	*ostreatus*	282	228
corticatus ? anneau non visible	not *acerinus*	283	291
geogenius forma *petaloides*	*petaloides*	284	258
serotinus	*serotinus*		

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
285	211	Agaricus (Pleurotus) mitis			
286	276			gadinoides	dictyorhizus
				limpidus	
				reniformis	...
287	242			lauro-cerasi	
				tremulus	malè
				acerosus	
288	259			porrigens	...
				septicus	...
289	243			mastrucatus	
				atrocoeruleus	...
290	260			Leightoni	algidus (junior)
				algidus	malè
291	244			fluxilis	...
				cyphellaeformis	
				applicatus	non! striatulus ?
292	212			Hobsoni	dictyorhizus
				striatulus	...
				hypnophilus	...
				chioneus	
293	293		(Volvaria)	bombycinus	...
294	294			volvaceus	...
295	295			Loveianus	= puberulus
296	296			Taylori	
297	297			speciosus	...
298	298			gloiocephalus	...
299	299			medius	...
300	300			temperatus	...
				parvulus	...
301	301		(Pluteus)	cervinus	...
302	565			— var. patricius	...
303	302			— var. eximius	...
304	357			— var. Bullii	...
305	303			— var. petasatus	...
306	304			umbrosus } hispidulus }	tous deux malè
307	517			ephebius	malè
308	597			pellitus	pas la spore
309	305			nanus	lutescens: chrysophaeus Q.
310	325			spilopus	cervinus
311	518			semibulbosus	
				violarius	Russula lateritia ou nitida
312	598			roseo-albus	non
313	421			leoninus	...
314	309			chrysophaeus	cervinus (gracilis)
315	422			phlebophorus	rhodopolius, leoninus ou Pleur. palmatus
316	310		(Entoloma)	sinuatus	= lividus ou clypeatus major
317	311			lividus	malè
318	469			— var. roseus	potius clypeatus
319	312			prunuloides	...
320	313			repandus	Inocybe repanda (Bull.) Quél.
321	314			placenta	elaphinum Fr. ?
322	339			helodes	prunuloides (genuinus)
323	373			helodes var.	Inocybe caesariata

MAIRE	REA	No. of bound volume	No. printed on Plate
mitis	mitis	285	211
dictyorhizus?	—	286	276
—	—		
—	—		
—	—	287	242
?	—		
acerosus	acerosus		
porrigens	porrigens	288	259
septicus	septicus		
mastrucatus	mastrucatus	289	243
atro-coeruleus	atro-coeruleus		
algidus	—	290	260
algidus?	algidus		
—	fluxilis	291	244
cyphelliformis	cyphellaeformis		
striatulus	applicatus		
dictyorhizus	—	292	212
striatulus	striatulus		
hypnophilus	hypnophilus		
chioneus	chioneus		
bombycina, non typique	—	293	293
volvacea	volvacea	294	294
Loveiana	Loveiana	295	295
Taylori	Taylori	296	296
speciosa	speciosa	297	297
speciosa, forme foncée (=gloiocephala)	gloiocephala	298	298
—	media	299	299
—	—	300	300
parvula	parvula		
cervinus	cervinus, stem characters poor	301	301
cervinus var. patricius	cervinus var. patricius	302	565
cervinus var. eximius	cervinus var. eximius, colour exaggerated	303	302
—	Bullii, a distinct species	304	357
rigens (Pers.) = salicinus Lange	cervinus var. petasatus	305	303
{ umbrosus Fr. non Pers., mais arête noire des lamelles non figurée { semibulbosus? ou hispidulus?	umbrosus } hispidulus }	306	304
—	—	307	517
—	—	308	597
{ nanus { nanus var. lutescens	nanus } lutescens }	309	305
?	spilopus	310	325
semibulbosus?	—	311	518
Un Lepiota ou Entoloma?	—		
palmatus	palmatus	312	598
{ leoninus { leoninus var. caloceps	leoninus typical	313	421
? forme grêle de P. cervinus	—	314	309
{ phlebophorus { palmatus	phlebophorus } palmatus }	315	422
clypeatum?	sinuatum	316	310
lividum, mauvaise figure	lividum	317	311
?	—	318	469
prunuloides, peu typique	—	319	312
?	prunuloides poor	320	313
—	—	321	314
prunuloides, forme foncée	—	322	339
—	—	323	373

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No. of bound volume	No. printed on Plate	COOKE			QUÉLET
324	315	*Agaricus (Entoloma) Persoonianus*			*Pluteus semibulbosus* ou *Lept. sericella* major ?
325	326	—	—	*Batschianus*	*madidus* (gracilis)
326	327	—	—	*Bloxami*	
327	328	—	—	*ardosiacus*	
328	581	—	—	*liquescens*	*Psathyra sarcocephala* avec spore de *Rhodophyllus*
329	341	—	—	*ameides*	malé, il est livide
330	470	—	—	*frumentaceus*	*Cortin. firmus* ?
331	306	—	—	*Saundersii*	*clypeatum* var. *albescens*
332	316	—	—	*fertilis*	*lividum*, malé
333	317	—	—	*jubatus*	
334	318	—	—	*resutus*	
		—	—	*griseocyaneus*	malé
335	307	—	—	*sericellus*	
336	374	—	—	*Thomsoni*	*scabiosum* ou *griseo-cyaneum*
337	319	—	—	*clypeus*	*clypeatum* Fr.
338	342	—	—	*rhodopolius*	*clypeatum*
339	329	—	—	*Wynnei*	*Pl. villosus*
340	320	—	—	*costatus*	
		—	—	*sericeus*	
341	321	—	—	*nidorosus*	
342	308	—	—	*speculum*	*Plut. pellitus*, non la spore
343	322	—	(*Clitopilus*) *prunulus*		trop blanc
344	323	—	—	*orcella*	
345	375	—	—	*mundulus*	pas blanc
		—	—	*cretatus*	*O. albula* ?
346	485	—	—	*popinalis*	
347	486	—	—	*undatus*	
348	501	—	—	*cancrinus*	
349	324	—	—	*carneo-albus*	
		—	—	*stilbocephalus*	*Nolanea incarnata*
350	599	—	—	*stilbocephalus* var.	*Coll. laccata*
351	487	—	—	*vilis*	*Lept. chalybaea* (vetusta)
352	330	—	(*Leptonia*) *placidus*		
353	331	—	—	*lampropus*	
354	332	—	—	*aethiops*	
		—	—	*solstitialis*	
355	333	—	—	*serrulatus*	*anatina* ?
356	334	—	—	*euchrous*	
357	335	—	—	*chalybeus*	
358	549	—	—	*lazulinus*	
359	336	—	—	*incanus*	*euchlorus*
360	488	—	—	*formosus* var. *suavis*	? malé
361	337	—	—	*chloropolius*	*Nolanea icterina* ?
362	376	—	(*Nolanea*) *pascuus*		
363	377	—	—	*Babingtonii*	pas blanc
		—	—	*mammosus*	
364	378	—	—	*pisciodorus*	
		—	—	*rufo-carneus*	*Lept. solstitialis* ou *C. laccata*
365	338	—	—	*icterinus*	
366	379	—	—	*piceus*	?
		—	—	*coelestinus*	
367	340	—	—	*verecundus*	
		—	—	*rubidus*	*Leptonia sericella*
368	380	—	(*Eccilia*) *parkensis*		
				carneo-griseus	

MAIRE	REA	No. of bound volume	No. printed on Plate
—	—	324	315
		325	326
Bloxamii = madidum	Bloxamii	326	327
Eccilia Mougeotii forma leptonidea	ardosiacum typical	327	328
L'hypothèse de Quélet est très vrai-semblable		328	581
ameides	ameides	329	341
Inocybe jurana Pat.=I. frumentacea Bres. (an Bull?)	rhodiola	330	470
—	Saundersii	331	306
lividum		332	316
porphyrophaeum	porphyrophaeum	333	317
—	—	334	318
griseocyaneum, mauvaise figure	griseocyaneum		
Lept. sericella	sericella	335	307
?	—	336	374
clypeatum Fr.	clypeatum, rather poor	337	319
rhodopolium Fr.?	rhodopolium	338	342
	—	339	329
costatum	costatum	340	320
sericeum	sericeum		
nidorosum	nidorosum	341	321
speculum	speculum	342	308
prunulus	prunulus	343	322
prunulus âgé	prunulus	344	323
pas mundulus	not mundulus	345	375
cretatus	cretatus		
	popinalis	346	485
—	—	347	486
? teinte de Collybia nitellina	cancrinus	348	501
Eccilia cancrina	sericella	349	324
Leptonia sericella?	stilbocephala		
Nolanea incarnata?	Smithii Massee	350	599
Laccaria laccata?	vilis	351	487
Eccilia Mougeotii?	placida	352	330
placida	lampropus	353	331
lampropoda	aethiops	354	332
—	solstitialis		
serrulata var. Berkeleyi Maire	serrulata var. Berkeleyi	355	333
euchroa	euchroa, larger than usual	356	334
chalybea	chalybea	357	335
—	lazulina poor	358	549
incana = euchlora	incana	359	336
	—	360	488
Nolanea icterina?		361	337
staurospora Bres. à spores mal figurées	proletaria	362	376
Babingtonii (trop pâle)		363	377
mammosa	mammosa		
Naucoria Cucumis	Cucumis	364	378
Nolanea infula?	rufo-carnea		
icterina	icterina	365	338
Naucoria Cucumis	Cucumis	366	379
?			
—	verecunda	367	340
Clitopilus cretatus? spores non angu-leuses	rubida		
—	—	368	380
	carneo-grisea		

No. of bound volume	No. printed on Plate	Cooke			Quélet
369	613	*Agaricus*	(*Eccilia*)	*griseo-rubellus*	malè
		—	—	*flosculus*	——
		—	—	*acus*	*sericellus*
370	343	—	—	*atro-punctus*	——
				rhodocyclus	
371	344	—	(*Claudopus*)	*variabilis*	——
		—	—	*depluens*	pas blanc
		—	—	*byssisedus*	blanc
372	345	—	(*Acetabularia*)	*acetabulosus*	Hyphol. fatuum, Psathyra torpens
373	346	—	(*Pholiota*)	*aureus*	——
374	347		—	— var. *Herefordensis*	benè, genuinus
375	348	—	—	*caperatus*	malè, plutòt *aureus*
376	349	—	—	*terrigenus*	——
377	358	—	—	*erebius*	pas violeté
378	359	—	—	*ombrophilus*	erebia ?
379	350	—	—	*togularis*	(non Bull.) Fr. = Arrhenii Fr.
380	423	—	—	*durus*	très blanc !
381	360	—	—	*praecox*	?
382	361	—	—	*radicosus*	——
383	362	—	—	*pudicus*	——
384	363	—	—	*leochromus*	aegerita (gracilis)
385	364	—	—	*capistratus*	aegerita (vetustior)
386	453	—	—	*aegerita*	malè, trop jaune
387	365	—	—	*aegerita*	——
388	600	—	—	*comosus*	= destruens Brond.
389	366	—	—	*heteroclitus*	destruens
390	351	—	—	*aurivellus*	——
391	367	—	—	*squarrosus*	benè
392	471	—	—	— var. *Mulleri*	——
393	614	—	—	— var. *verruculosus*	——
394	352	—	—	*spectabilis*	aureus
395	353	—	—	*adiposus*	——
396	368	—	—	*flammans*	malè
397	369	—	—	*junonius*	? aurea (gracilior)
398	370	—	—	*tuberculosus*	——
				curvipes	
399	502	—	—	*cruentatus*	ou Flammula azyma Fr. ?
400	371	—	—	*dissimulans*	Ph. erebia
401	354	—	—	*Cookei*	ou gummosa
402	355	—	—	*mutabilis*	——
403	372	—	—	*marginatus*	unicolor
404	356	—	—	*mustelinus*	——
				unicolor	marginata
405	503	—	—	*pumilus*	var. humicola
				mycenoïdes	?
406	424	—	(*Inocybe*)	*hystrix*	——
407	389	—	—	*calamistratus*	——
408	582	—	—	*lanuginosus*	dulcamara
				dulcamarus	lucifuga
409	425	—	—	*plumosus*	——
				cincinnatus	
410	390	—	—	*haemactus*	corydalina (vetustior)
411	472	—	—	*pyriodorus*	? caesariata
412	473	—	—	*incarnatus*	repanda
413	391	—	—	*scaber*	——

Maire	Rea	No. of bound volume	No. printed on Plate
?	*griseo-rubella*	369	613
	flosculus		
Leptonia sericella (forme décurrente)	*acus*		
——	*atro-puncta*	370	343
——			
variabilis	*variabilis*	371	344
——	*depluens*		
byssisedus (trop gris)	*byssisedus*		
Bolbitius bulbillosus	*acetabulosa*	372	345
spectabilis	*aurea*	373	346
aurea Fr. non Quél., forme colorée	*aurea*	374	347
aurea Fr. non Quél.	——	375	348
Flammula gummosa	*ochrochlora* typical	376	349
erebia (trop violacé)	*erebia*	377	358
Peut-être un gros *Stropharia inuncta*?	*ombrophila*, very large example	378	359
togularis Fr. non Ricken	*togularis*	379	350
dura (trop coloré)	*dura*	380	423
{ *praecox* (fig. sup.) } { *dura* (fig. inf.) }	*praecox*	381	360
Hebeloma radicosum	*radicosum*	382	361
cylindracea = aegerita	*aegerita*	383	362
cylindracea	*leochroma*	384	363
cylindracea forma *fuscescens*	*aegerita*	385	364
cylindracea forma *fuscescens*	*aegerita*	386	453
cylindracea forma	*aegerita*	387	365
destruens	*destruens*	388	600
destruens forma	*destruens*	389	366
aurivella ou *adiposa*?	*aurivella*	390	351
squarrosa	*squarrosa*	391	367
Mulleri (espèce distincte)	*Mulleri*	392	471
squarrosa (forme pâle)	*squarrosa* var. *verruculosa*	393	614
spectabilis	*spectabilis*	394	352
adiposa	*adiposa*	395	353
flammans	*flammans*	396	368
spectabilis, forme grêle	*Junonia*	397	369
?	*squarrosa* var. *verruculosa*	398	370
curvipes	*curvipes* (flesh of stem darker)		
——	*cruentata*	399	502
ombrophila?	*dissimulans*	400	371
Flammula gummosa	*ochrochlora*	401	354
mutabilis	*mutabilis*	402	355
unicolor	*unicolor*	403	372
——	*mustelina*	404	356
marginata	*marginata*		
marginata	*pumila*	405	503
?	*togularis*		
hystrix	*hystrix*	406	424
calamistrata	*calamistrata*	407	389
dulcamara?	*dulcamara*	408	582
lucifuga	*dulcamara*		
?	*plumosa* prob., but no spores	409	425
lanuginosa	*lanuginosa*		
piriodora ssp. *haemacta*	*haemacta*	410	390
piriodora	*pyriodora*	411	472
jurana Pat.	*incarnata*	412	473
——	*scabra*	413	391

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
414	392	Agaricus (Inocybe)		maritimus	lanuginosa
415	583	—	—	lacerus	—
416	393	—	—	flocculosus	rimosus (gracilis)
417	381	—	—	Bongardii	rimosa
418	382	—	—	muticus	—
419	426	—	—	carptus	forma robusta : hirsuta ?
420	394	—	—	deglubens	caesariata
421	427	—	—	obscurus	{ obscura { cincinnata
422	395	—	—	echinatus	Inocybe ? ?
423	504	—	—	schistus	rimosa ou fastigiata
424	454	—	—	fibrosus	bené
425	396	—	—	phaeocephalus	rimosa vel brunnea
426	383	—	—	fastigiatus	tomentosa
427	397	—	—	hiulcus	repanda Bull.
428	398	—	—	Curreyi	caesariata ?
429	384	—	—	rimosus	—
430	385	—	—	asterosporus	—
431	386	—	—	eutheles	—
432	505	—	—	margaritispora	? lacera (vetustissima) pas la spore
433	387	—	—	destrictus	—
434	519	—	—	perbrevis	Cortinarius incisus Fr.
435	428	—	—	descissus	—
		—	—	Trinii	scabella
436	399	—	—	sambucinus	—
437	388	—	—	caesariatus	capucina Fr.
438	400	—	—	sindonius	geophila (luxurians)
439	429	—	—	lucifugus	malé
		—	—	Clarkii	geophila ou tomentosa
440	401	—	—	geophyllus	—
441	402	—	—	scabellus	malé
442	520	—	—	Rennyi	fusca ?
443	403	—	—	trechysporus	plumosus ?
		—	—	vatricosus	tomentosus
444	404	—	—	Whitei	lucifuga ?
		—	—	tricholoma	
445	405	—	(Hebeloma)	mussivus	—
446	406	—	—	fastibilis	—
447	407	—	—	senescens	—
448	430	—	—	glutinosus	—
449	408	—	—	testaceus	?
450	409	—	—	firmus	{ forme de crustuliniformis { aspect de Cortinarius { imbutus ou varius }
451	410	—	—	claviceps	versipellis
452	411	—	—	mesophaeus	versipellis
453	412	—	—	— forma minor	?
454	506	—	—	subcollariatus	versipellis
455	413	—	—	sinapizans	crustuliniformis B.
456	507	—	—	crustuliniformis	—
457	414	—	—	— forma minor	—
458	415	—	—	longicaudus	elatus
459	416	—	—	— var. radicatus	versipellis
460	417	—	—	truncatus	—
461	418	—	—	nudipes	elatus
462	419	—	—	capniocephalus	versipellis

Maire	Rea	No. of bound volume	No. printed on Plate
?	maritima	414	392
? non *lacera* Ricken	—	415	583
?	flocculosa	416	393
? non *Bongardii*	not *Bongardii*	417	381
?	mutica	418	382
?	—	419	426
?	deglubens	420	394
obscura	— }	421	427
cincinnata?	— }		
Lepiota echinata	Lepiota haematosperma	422	395
? ? *Entoloma* sp. ?	schista	423	504
—	fibrosa	424	454
maculata Boud. ?	phaeocephala	425	396
fastigiata	—	426	383
?	Godeyi	427	397
?	fastigiata	428	398
Queletii?	probably *Queletii*	429	384
asterospora = *rimosa* Fr. genuina	asterospora	430	385
eutheles	tomentosa	431	386
—	margaritispora	432	505
—	destricta	433	387
non *perbrevis. Cort. incisus* ?	—	434	519
?	—	435	428
scabella	*Trinii*		
	sambucina	436	399
	caesariata	437	388
—	—	438	400
geophylla var. *alba*?			
lucifuga	lucifuga	439	429
geophylla var. *alba*?	—		
geophylla var. *alba* et *violacea*	geophylla	440	401
?	—	441	402
?	—	442	520
trechispora	trechyspora	443	403
—	—		
	—	444	404
Ripartites Tricholoma	tricholoma		
—	—	445	405
fastibile?	*fastibile*, pileus too deep in colour	446	406
senescens	senescens	447	407
Flammula lenta	glutinosum, pileus too dark	448	430
? pied ordinairement bulbeux	testaceum	449	408
?	—	450	409
versipelle var.	—	451	410
{ fig. sup. *versipelle*	versipelle }	452	411
{ fig. inf. *versipelle* var. *mesophaeum*	mesophaeum }		
versipelle var. *mesophaeum*	mesophaeum	453	412
—		454	506
sinapizans	sinapizans	455	413
sinapizans forma	crustuliniforme	456	507
crustuliniforme	crustuliniforme var. *minus*	457	414
longicaudum?	longicaudum	458	415
radicatum	radicatum	459	416
Rhodopaxillus truncatus ? ? spores trop grandes et trop amygdaliformes	*Tr. truncatum*	460	417
	—	461	418
versipelle var. *mesophaeum*	mesophaeum	462	419

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
463	420	Agaricus	(Hebeloma)	ischnostylus	elatus (gracilis) ou saccha-riolens
464	508	—	—	magnimamma	sersipellis
		—	—	petiginosus	non! mesophaeum
465	431	—	(Flammula)	gymnopodius	? malè
466	437	—	—	vinosus	pas la couleur, Pleur. Eryngii ?
467	438	—	—	floccifer	Heb. glutinosum
		—	—	decipiens	
468	500	—	—	clitopilus	Tricholoma truncatum ?
469	439	—	—	lentus	
470	440	—	—	long-stemmed form	—
471	474	—	—	mixtus	carbonarius
472	475	—	—	juncinus	alnicola
473	441	—	—	gummosus	spumosa ?
474	476	—	—	spumosus	
475	442	—	—	carbonarius	?
476	432	—	—	filius	? Cortinarius
477	433	—	—	fusus	Heb. senescens
478	434	—	—	variety	Pholiota aurea
479	435	—	—	astragalinus	malè
480	443	—	—	alnicola	
481	444	—	—	flavidus	spumosus
482	477	—	—	inauratus	hybrida
483	445	—	—	conissans	? ?
484	446	—	—	inopus	malè
485	436	—	—	apicreus	
486	615	—	—	hybridus	Pholiota confragosa
487	447	—	—	sapineus	
488	448	—	—	picreus	liquiritiae
489	616	—	—	ochrochlorus	gummosa
490	449	—	—	helomorphus	
		—	—	scambus	
491	450	—	—	filiceus	? graminis
492	451	—	(Naucoria)	cidaris	malè
493	452	—	—	Cucumis	
494	455	—	—	anguineus	copiés de Fries
495	601	—	—	centunculus	
		—	—	horizontalis	
496	509	—	—	semiflexus	
		—	—	rimulincola	horizontalis
		—	—	rubricatus	Marasmius ramealis
497	456	—	—	abstrusus	pellucida
498	489	—	—	innocuus	Flam. carbonaria
		—	—	cerodes	Pluteolus dictyotus Kalch.
499	457	—	—	melinoides	
		—	—	pusiolus	malè
500	490	—	—	nuceus	
		—	—	glandiformis	—
501	491	—	—	badipes	
		—	—	scolecinus	
502	478	—	—	striaepes	Pluteolus dictyotus
503	458	—	—	sideroides	malè
		—	—	triscopus	malè
504	617	—	—	vervacti	
		—	—	tenax	autochthona
505	492	—	—	pediades	

MAIRE	REA	No. of bound volume	No. printed on Plate
sacchariolens?	sacchariolens	463	420
Inocybe sp.	—	464	508
Inocybe fastigiata? forma	—		
Clitocybe olearia? mais chair trop blanche	sapinea	465	431
Pleurotus Eryngii?	—	466	437
lenta	—	467	438
?	decipiens	468	500
lenta	glutinosum	469	439
lenta	glutinosum	470	440
carbonaria (grêle)	carbonaria	471	474
alnicola?	—	472	475
—	—	473	441
—	—	474	476
carbonaria	carbonaria, large form	475	442
?	—	476	432
H. senescens?	—	477	433
forme décurrente stérile de *Pholiota spectabilis*?	—	478	434
rubicundula Rea	rubicundula	479	435
alnicola	alnicola	480	443
—	flavida	481	444
—	inaurata	482	477
conissans, mauvaise figure	conissans	483	445
Hypholoma epixanthum Fr.? Quél.!	Hypholoma radicosum Lange	484	446
	apicrea	485	436
Ph. confragosa	confragosa	486	615
sapinea	sapinea	487	447
—	—	488	448
?	ochrochlora	489	616
?	helomorphus, spore wrong	490	449
Ripartites Tricholoma	scamba		
—	—	491	450
—	—	492	451
Cucumis	Cucumis	493	452
d'après Fries	anguinea	494	455
centunculus, trop pâle	centunculus	495	601
horizontalis	horizontalis		
—	—	496	509
rimulincola	—		
Mar. ramealis	ramealis		
?	furfuracea	497	456
Flam. carbonaria	—	498	489
?	cerodes		
—	melinoides	499	457
—	pusiola		
?	—	500	490
Cortinarius	—		
badipes	badipes	501	491
—	escharoides		
striipes	striaepes	502	478
—	—	503	458
Galera triscopa	—		
vervacti	vervacti	504	617
? n'a pas la teinte de *N. autochthona*	—		
pediades	pediades	505	492

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
506	479	Agaricus (Naucoria)	arvalis		
507	493	—	—	semiorbicularis	
		—	—	tabacinus	
508	494	—	—	myosotis var. major	malè, Cortinarius
509	459	—	—	temulentus	malè
510	482	—	—	latissimus	Coll. extuberans ? Ps. spadicea
511	510	—	—	porriginosus	Cortin. scandens
512	511	—	—	sobrius	crobulus
		—	—	— var. dispersus	
513	480	—	—	erinaceus	
		—	—	siparius	? il est humicole
514	512	—	—	conspersus	malè
		—	—	escharoides	malè
515	513	—	—	carpophilus	
		—	—	graminicola	inquilina
516	495	— (Pluteolus)	reticulatus		
517	460	— (Galera)	lateritius		Bolbitius apalus
518	461	—	—	tener	
		—	—	— var. pilosellus	
519	462	—	—	ovalis	tenera
520	463	—	—	antipus	tenera
		—	—	confertus	
521	481	—	—	sparteus	
		—	—	pygmaeo-affinis	
522	464	—	—	vittaeformis	malè
		—	—	rubiginosus	
523	465	—	—	hypnorum	
		—	—	hypnorum	
524	466	—	—	mniophilus	malè
		—	—	minutus	est humicole
525	467	—	—	ravidus	malè
		—	—	mycenopsis	Myc. epipterygia
526	602	— (Tubaria)	cupularis (var.)		pellucida
527	603	—	—	furfuraceus	
528	483	—	—	— var. trigono-phyllus	
529	484	—	—	paludosus	
530	468	—	—	stagninus	
531	514	—	—	embolus	
		—	—	autochthonus	undulatus Bull.
532	496	—	—	crobulus	
533	497	—	—	inquilinus	malè
534	499	— (Crepidotus)	alveolus		
		—	—	calolepis	
535	498	—	—	mollis	
536	515	—	—	haustellaris	
		—	—	Rubi	
		—	—	Phillipsii	
		—	—	chimonophilus	variabilis
537	516	—	—	epigaeus	applanatus
		—	—	Ralfsii	
		—	—	epibryus	
		—	—	pezizoides	Pleurot. craterellus
538	521	— (Psalliota)	augustus		villatica ?
539	522	—	—	Elvensis	
540	523	—	—	arvensis	
541	584	—	—	— var. purpurascens	sylvatica var. rubella Gill.
542	524	—	—	cretaceus	Lepiota pudica

MAIRE	REA	No. of bound volume	No. printed on Plate
arvalis	*arvalis*	506	479
semiorbicularis	*semiorbicularis*	507	493
tabacina?	*tabacina*		
——	*Myosotis* typical	508	494
Tubaria pellucida? mais spores trop grandes, et voile non figuré	*temulenta*	509	459
?	——	510	482
?	——	511	510
Tubaria crobulus	*sobria*	512	511
?	*pusiola*		
erinacea	*erinacea*	513	480
potius *Lepiota*	*siparia*		
conspersa	*conspersa*	514	512
escharoides?? spore trop allongée	not *escharoides*		
carpophila	*carpophila*	515	513
Tubaria inquilina?	*graminicola*		
reticulatus	*reticulatus*	516	495
lateritia	——	517	460
tenera	*tenera*	518	461
e grege *G. tenerae*	*pilosella*		
tenera	*ovalis*	519	462
antipoda	*antipus*	520	463
——	——		
spartea	*spartea*	521	481
pygmaeo-affinis	*pygmaeo-affinis*		
vittiformis? teintes du chapeau fausses	——	522	464
	rubiginosa		
Hypnorum	*hypnorum*	523	465
Sphagnorum	——		
lateritia?	——	524	466
inquilina?			
?	——	525	467
Myc. epipterygia?	not *mycenopsis*		
pellucida	*pellucida*	526	602
furfuracea	*furfuracea*	527	603
furfuracea forma	*furfuracea* var. *trigonophylla*	528	483
paludosa	*paludosa*	529	484
stagnina	*stagnina*	530	468
		531	514
autochthona	*autochthona*		
crobulus	*crobulus*	532	496
inquilina?	*inquilina*	533	497
palmatus?	*alveolus*	534	499
calolepis	*calolepis*		
mollis	*mollis*	535	498
		536	515
Nauc. effugiens	*effugiens*		
Phillipsii	*Phillipsii*		
——	——		
applanatus Quél. (an Fr.?)	——	537	516
	Ralfsii		
n'est pas *P. craterellus*	——		
Agaricus augustus	*Psaliota augusta*	538	521
Elvensis	*Elvensis*	539	522
arvensis Fr., Quél., non Pat.	*arvensis*	540	523
silvicola Vitt. var. *purpurascens* Cke.	*sylvicola* var. *purpurascens*	541	584
xanthodermus Genev. var. *lepiotoides* Maire ou *Lep. naucina*	*lepiotoides* Maire	542	524

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No. of bound volume	No. printed on Plate	COOKE	QUÉLET
543	525	*Agaricus* (*Psalliota*) *pratensis*	
544	526	— — *campestris*	*villatica* Brond.
545	527	— — — var. *hortensis*	*villatica*
546	528	— — — var. *costatus*	champignons altérés
		— — — var. *exannu-latus*	*villatica*
547	529	— — — var. *sylvicola*	*sylvatica*, male
548	585	— — — var. *villaticus*	
549	530	— — *sylvaticus*	male
		— — *sylvaticus*	
550	531	— — *haemorrhoidarius*	
551	532	— — *subgibbosus* (var.)	*Pholiota aegerita*, vetustior
552	533	— — *comtulus*	
553	618	— (*Pilosace*) *Algeriensis*	?
554	550	— (*Stropharia*) *Percevali*	*Flammula spumosa*
555	551	— — *aeruginosus*	
556	552	— — *albo-cyaneus*	*aeruginosa*
557	534	— — *inunctus*	male
558	535	— — *coronillus*	lamelles brun-pourpre
559	536	— — *melaspermus*	bene
560	553	— — *squamosus*	
561	554	— — *thraustus*	
562	555	— — — var. *auranti-acus*	? *ericetorum*
563	556	— — *Worthingtoni*	*aeruginosa*
564	604	— — *luteo-nitens*	*Hyph. appendiculatum* Bull.
565	537	— — *merdarius*	*Flammula carbonaria*
566	538	— — *stercorarius*	*semiglobata*
567	539	— — *semi-globatus*	
568	540	— — *caput-medusae*	? *cotonea*, vetustior
569	541	— — *Jerdoni*	*squamosa*
570	542	— — *spintriger*	
571	619	— — *hypsipus*	*Hyph. Candolleanum*
572	557	— (*Hypholoma*) *sublateritius*	
573	558	— — — var. *squamosus*	
574	559	— — *capnoides*	
575	560	— — *epixanthus*	
576	561	— — *fascicularis*	
577	562	— — — var. *elaeodes*	
578	586	— — *dispersus*	male
579	587	— — *oedipus*	*Stroph. versicolor*
		— — *punctulatus*	
580	543	— — *storea* var. *caespi-tosus*	*Stroph. cotonea*
581	566	— — *lacrymabundus*	? *cotonea*, vetustior
582	563	— — *velutinus*	
583	564	— — *pyrotrichus*	
584	544	— — *cascus*	*appendiculatum*
585	545	— — *lanaripes*	*appendiculatum*, vetustius
586	546	— — *Candolleanus*	*appendiculatum*
587	547	— — *appendiculatus*	male
588	548	— — *leucotephrus*	*appendiculatum*
589	605	— — *egenulus*	*Psathyra cernua*
		— — *hydrophilus*	male
590	567	— (*Psilocybe*) *sarcocephalus*	

MAIRE	REA	No. of bound volume	No. printed on Plate
pratensis ?	*pratensis*	543	525
campestris	*campestris*	544	526
villaticus ?	*hortensis* as species	545	527
haemorrhoidarius ? forme pâle			
forme de *pratensis* ?	varieties of *campestris*	546	528
silvicola ? pas assez blanc	*sylvicola* as species	547	529
villaticus	*villatica* as species	548	585
silvaticus ?	*sylvatica*	549	530
silvicola var.	*perrara*		
haemorrhoidarius	*haemorrhoidaria*	550	531
Ph. cylindracea (= *aegerita*)	⸺	551	532
comtulus	*comtula*	552	533
forme à très grandes spores qui reste inconnue	⸺	553	618
forme de *Stroph. depilata* Fr. (teste Plowright)	*Percevalii*, distinct from *depilata*	554	550
aeruginosa	*aeruginosa*	555	551
aeruginosa var. *albo-cyanea*	*albocyanea*	556	552
inuncta	*inuncta*	557	534
coronilla	*melasperma* var. *lutescens*	558	535
melasperma	*melasperma*	559	536
squamosa	*squamosa*	560	553
squamosa ayant perdu les squamules du chapeau ?	*squamosa* var. *thrausta*	561	554
?	*squamosa* var. *aurantiaca*	562	555
aeruginosa var. *Worthingtonii*	*albo-cyanea*	563	556
?	⸺	564	604
merdaria ?	*merdaria*	565	537
stercoraria = *semiglobata*	*stercoraria*	566	538
stercoraria = *semiglobata*	*semiglobata*	567	539
caput-medusae	*caput-Medusae*	568	540
Hyph. lacrimabundum Fr. ?	⸺	569	541
spintrigera	*spintrigera*	570	542
?	*hypsipus*	571	619
sublateritium	*sublateritium*	572	557
sublateritium forma *squamosum*	*sublateritium* var. *squamosum*	573	558
capnoides	*capnoides*	574	559
fasciculare ?	*epixanthum*	575	560
fasciculare	*fasciculare*	576	561
?	not *elaeodes*	577	562
dispersum peu typique	not *dispersum*	578	586
melantinum ?	⸺	579	587
⸺			
lacrimabundum Fr. non Quél. nec Bull.	*lacrymabundum* Fr.	580	543
idem	*caput, Medusae*	581	566
velutinum	*velutinum*	582	563
velutinum var. *pyrotrichum*	*pyrotrichum*	583	564
Candolleanum	*cascum*	584	544
Candolleanum forma ?	*appendiculatum*	585	545
Candolleanum	⸺	586	546
Candolleanum, mais la forme grêle cespiteuse à gauche est peut-être *P. cernua*	*appendiculatum*	587	547
leucotephrum, me paraît distinct	*leucotephrum*	588	548
Candolleanum ?	⸺	589	605
hydrophilum, mauvaise figure	⸺		
sarcocephala	*sarcocephala*	590	567

No. of bound volume	No. printed on Plate	Cooke		Quélet
591	620	*Agaricus (Psilocybe)*	*sarcocephalus*	—
592	568	—	— *ericaeus*	—
593	588	—	— *sub-ericaeus*	—
594	569	—	— *udus*	—
595	621	—	— *canofaciens*	—
596	570	—	— *areolatus*	*Fl. epixantha*
597	622	—	— *agrarius*	*Mycena sudora*
598	607	—	— *scobicula*	*Hyph. appendiculatum*
599	606	—	— *chondrodermus*	—
		—	— *ammophilus*	*Cort. milvinus*
600	608	—	— *coprophilus*	malè
		—	— *bullaceus*	malè
601	609	—	— *physaloïdes*	malè, pas carminé
		—	— *nucisedus*	*Tub. inquilina*
602	571	—	— *atrorufus*	malè; *Psathyra corrugis*?
603	589	—	— *comptus*	*Pluteolus apalus*
		—	— *hebes*	—
604	572	—	— *semilanceatus*	—
605	573	—	— — var. *coerulescens*	—
606	610	—	— *spadiceus*	—
607	574	—	— *cernuus*	—
608	590	—	— *foenisecii*	—
609	575	—	*(Psathyra) conopileus*	*Panaeolus fimiputris*
610	591	—	— *mastiger*	*Cort. acutus*
		—	— *glareosus*	*Mycena zephirus*
611	576	—	— *corrugis*	*Hyph. appendiculatum*
612	592	—	— — var. *vinosus*	*Hyph. appendiculatum*
613	577	—	— *pellospermus*	*Nolanea incarnata*
614	611	—	— *spadiceo-griseus*	*Hypholoma*
615	593	—	— *obtusatus*	*Hyph. fibrillosum*
616	594	—	— *bifrons*	*Pan. acuminatus*
		—	— var. *semitinctus*	*Psathyrella gracilis*
617	578	—	— *semivestitus*	—
618	595	—	— *fatuus*	malè
		—	— *fibrillosus*	—
619	579	—	— *helobius*	*fatua*
620	580	—	— *Gordoni*	*pennata*
		—	— *pennatus*	—
621	612	—	— *gossypinus*	—
		—	— *noli-tangere*	—
622	596	—	— *microrhizus*	*bifrons*
		—	— *urticaecola*	*gyroflexa*, minor
623	623	—	*(Panaeolus) separatus*	malè
624	624	—	— *egregius*	*Strop. lacrymabunda* Bull.
625	927	—	— *leucophanes*	*separatus*
		—	— *scitulus*	*Copr. ephemeroides*
626	625	—	— *fimiputris*	*campanulatus*
627	626	—	— *phalenarum*	—
628	627	—	— *retirugis*	—
629	628	—	— *sphinctrinus*	—
630	629	—	— *campanulatus*	*conocephalus*
631	630	—	— *papilionaceus*	—
632	631	—	— *caliginosus*	*acuminatus*
		—	— *subbalteatus*	—
633	632	—	— *acuminatus*	malè
		—	— *fimicola*	*acuminatus*
634	633	—	*(Psathyrella) subatratus*	—

Maire	Rea	No. of bound volume	No. printed on Plate
sarcocephala var. _spadicea_	—	591	620
ericaea	_ericaea_	592	568
sub-ericaea?	_subericaea_	593	588
Hyph. elongatum (Fr.) Ricken?	_elongata_	594	569
Psathyra helobia?	—	595	621
?	—	596	570
?	—	597	622
Hyph. Candolleanum forma?	—	598	607
?	—	599	606
ammophila	_ammophila_		
coprophila	_coprophila_	600	608
bullacea	_bullacea_		
physaloides?	_physaloides_	601	609
inquilina?	_inquilina_		
corrugis?	—	602	571
Galera apala?	—	603	589
	hebes		
semilanceata	_semilanceata_	604	572
	var. _coerulescens_	605	573
H. hydrophilum	_hydrophilum_	606	610
cernua?	_cernua_	607	574
foenisecii	_foenisecii_, typical except spores	608	590
Psathyrella subatrata?	_conopilea_	609	575
Cort. acutus?	—	610	591
Myc. zephirus?	—		
P. conopilea? spores trop grandes pour _H. appendiculatum_	_corrugis_	611	576
Hyph. Candolleanum	—	612	592
P. fatua?	—	613	577
?	—	614	611
?	—	615	593
?	_bifrons_	616	594
gracilis	var. _semitincta_		
semivestita	_semivestita_	617	578
?	_fatua_	618	595
?	_fibrillosa_		
helobia? pas typique	—	619	579
?	—	620	580
pennata	_pennata_		
gossypina?	_gossypina_	621	612
Psathyrella caudata?	—	622	596
P. gyroflexa?	_urticaecola_		
Anellaria separata	_separata_	623	623
Hyph. velutinum Fr.	—	624	624
Anellaria separata?	—	625	927
Copr. ephemeroides?	—		
campanulatus	_fimiputris_	626	625
fimiputris?	_campanulatus_	627	626
retirugis	_retirugis_	628	627
sphinctrinus	_sphinctrinus_	629	628
campanulatus	_campanulatus_	630	629
papilionaceus	_papilionaceus_	631	630
spores plutôt de _campanulatus_	_campanulatus_, small form	632	631
?	—	633	632
acuminatus	not _fimicola_		
subatrata	_subatrata_	634	633

No. of bound volume	No. printed on Plate	COOKE	QUÉLET
635	634	*Agaricus (Psathyrella) gracilis*	*Psathyra corrugis*
636	635	— — *hiascens*	malè
637	636	— — *aratus*	*Psathyra conopilea*
638	655	— — *trepidus*	?
		— — *hydrophorus*	——
639	637	— — *caudatus*	——
640	656	— — *pronus*	*crenata*
		— — *pronus*	—
641	657	— — *empyreumaticus*	*Nauc. temulenta*
		— — *disseminatus*	
642	638	— — *atomatus*	*corrugis* *gracilis*
643	847	— — *crenatus*	*impatiens* ?
644	658	*Coprinus comatus*	
645	659	— *ovatus*	——
646	660	— *sterquilinus*	malè
647	661	— *oblectus*	?
648	662	— *atramentarius*	
649	848	— *soboliferus*	forme de *fuscescens*
650	663	— *fuscescens*	*hydrophorus* ou *micaceus*
651	664	— — var. *rimoso-squamosus*	*deliquescens* Bull.
652	665	— *picaceus*	
653	666	— *aphthosus*	*Hyph. appendiculatum*
654	667	— *flocculosus*	*H. Candolleanum*
655	668	— *extinctorius*	——
656	669	— *fimetarius* var. *pullatus*	——
657	670	— — var. *macrorhizus*	——
658	671	— *cinereus*	——
659	672	— *tomentosus*	——
		— *niveus*	sur crottin, non sur aiguilles
660	673	— *micaceus*	! sublime de l'art
661	674	— *aratus*	*micaceus* forme
662	675	— *aratus*	*domesticus*
663	676	— *radians*	——
		— *papillatus*	*Psathyrella crenata*
664	677	— *alternatus*	*Panaeolus phalenarum*
665	678	— *deliquescens*	malè, *exstinctorius* ?
666	719	— *tardus*	
667	679	— *congregatus*	——
668	680	— *Hendersonii*	
		— *narcoticus*	*niveus*
669	681	— *lagopus*	——
670	682	— *macrocephalus*	*Psathyra pennata*
		— *nycthemerus*	malè
671	683	— *radiatus*	malè
		— *Spraguei*	*Psathyrella crenata*
672	684	— *domesticus*	malè
673	685	— *stercorarius*	malè
		— *ephemerus*	——
674	686	— *plicatilis*	malè
		— *filiformis*	*sceptrum*
675	687	— *hemerobius*	*hiascens*
		— *platypus*	——
676	688	*Hiatula Wynniae*	*Coprinus narcoticus* ?
677	689	*Bolbitius Boltoni*	*vitellinus*
678	928	— *vitellinus*	*Hygroph. chlorophanus*
		— *rivulosus*	*titubans* ou *Gal. tenera*
679	720	— *fragilis*	*titubans*
		— *apicalis*	forme maladive
680	690	— *titubans*	——

Maire	Rea	No. of bound volume	No. printed on Plate
corrugis ?	gracilis	635	634
?	hiascens	636	635
?	—	637	636
?	—	638	655
Copr. plicatilis ou crenatus ?			
caudata	caudata, large form	639	637
disseminata	disseminata	640	656
?	—		
Nauc. temulenta	—	641	657
disseminata	disseminata		
corrugis	—	642	638
gracilis	gracilis		
?	crenata typical	643	847
comatus	comatus	644	658
ovatus	ovatus var. of comatus	645	659
sterquilinus	sterquilinus	646	660
sterquilinus forma	oblectus	647	661
atramentarius	atramentarius	648	662
atramentarius forma	atramentarius var. soboliferus	649	848
micaceus, trop foncé	fuscescens	650	663
micaceus ?	fuscescens var.	651	664
picaceus	picaceus	652	665
Hyph. lacrimabundum Fr.		653	666
?	flocculosus	654	667
extinctorius	—	655	668
fimetarius	cinereus	656	669
fimetarius	macrorhizus	657	670
cinereus	cinereus	658	671
tomentosus	—	659	672
niveus	niveus		
micaceus	micaceus	660	673
micaceus ?	—	661	674
?	—	662	675
radians	radians	663	676
?	—		
?	—	664	677
?	—	665	678
Psathyra cernua ?	—	666	719
congregatus	congregatus	667	679
Hendersonii	Hendersonii	668	680
?	—		
lagopus	lagopus	669	681
?	—	670	682
?	—		
radiatus ?	radiatus	671	683
crenatus ?	—		
?	—	672	684
?	—	673	685
ephemerus	ephemerus		
plicatilis	plicatilis	674	686
?	—		
plicatilis	hemerobius	675	687
?	—		
?	—	676	688
vitellinus ?	vitellinus	677	689
vitellinus ?	vitellinus	678	928
?	—		
titubans	fragilis	679	720
apicalis	—		
titubans	titubans	680	690

No. of bound volume	No. printed on Plate	COOKE		QUÉLET
681	691	*Bolbitius tener*		*Galera apala* Fr.
682	692	*Cortinarius (Phlegmacium) triumphans*		*crocolitus*
683	693		*claricolor*	——
684	694	——	*turmalis*	*claricolor*
685	695	——	*crassus*	*torvus*, vetustior
686	696	——	*balteatus*	*variicolor*!
687	697	——	*sebaceus*	benè
688	799	——	*lustratus*	*argenteus*
689	698	——	*varius*	——
690	699	——	*cyanopus*	——
691	700	——	*variicolor*	*torvus*
692	863	——	—— var. *nemorensis*	——
693	701	——	*largus*	malè
694	702	——	*Riederi*	
695	703	——	*saginus*	*triumphans* forme
696	751	——	*russus*	*brunneo-fulvus*
697	704	——	*infractus*	*cotoneus* ou *prasinus*
698	705	——	*anfractus*	*infractus*
699	706	——	*Berkeleyi*	*torvus*! vetustus
700	707	——	*Berkeleyi*	*torvus*
701	708	——	*multiformis*	
702	709	——	—— var. *flavescens*	——
703	710	——	*napus*	*turbinatus*
704	752	——	*allutus*	*Lactarius pubescens* ou *Cort. cinnabarinus* décoloré
705	711	——	*talus*	
706	712	——	*glaucopus*	
707	713	——	*calochrous*	
708	721	——	*coerulescens*	pas la teinte { *dibaphus* }
709	722	——	*coerulescens*	{ ? }
710	723	——	*purpurascens*	!
711	724	——	*purpurascens*	
712.	725	——	—— var. *sub-purpurascens*	
713	753	——	*dibaphus* var. *xanthophyllus*	*turbinatus* forme
714	714	——	*turbinatus*	
715	715	——	*corrosus*	
716	716	——	*fulgens*	
717	717	——	*fulmineus*	
718	754	——	*orichalceus*	benè
719	735	——	*prasinus*	
720	736	——	*atro-virens*	
721	755	——	*scaurus*	malè
722	849	——	*herpeticus*	*glaucopus*
723	726	——	*cumatilis*	malè
724	727	——	*emollitus*	*ochroleucus*
725	728	——	*cristallinus*	*causticus*
726	729	——	*decoloratus*	
727	730	——	*decolorans*	——
728	731	——	*porphyropus*	
729	732	——	*croceo-coeruleus*	malè
730	733	——	*corruscans*	*sebaceus*
731	718	——	*papulosus*	*multiformis*
732	737	—— (*Myxacium*)	*arvinaceus*	*sebaceus*
733	738	——	*collinitus*	—— (luxurians)
734	739	——	*mucosus*	malè
735	740	——	*mucifluus*	*collinitus*
736	741	——	*elatior*	——

MAIRE	REA	No. of bound volume	No. printed on Plate
Galera apala?	*tener*	681	691
crocolitus	*triumphans*	682	692
claricolor forme	*claricolor*	683	693
turmalis	—	684	694
praestans Cordier	—	685	695
variicolor	*balteatus*	686	696
—	*sebaceus*	687	697
argenteus?	—	688	799
varius? plutôt forme de *largus*	*varius*	689	698
largus jeune?	*cyanopus*	690	699
praestans	*praestans*	691	700
largus?	*variicolor* var. *nemorensis*	692	863
largus	*largus*	693	701
?	—	694	702
triumphans	*triumphans*	695	703
brunneo-fulvus?	—	696	751
?	*infractus*	697	704
infractus	*infractus*	698	705
praestans	*praestans*	699	706
praestans	*praestans*	700	707
multiformis	*multiformis*	701	708
elegantior?	*elegantior*	702	709
?	*napus*	703	710
?	—	704	752
multiformis	*multiformis*	705	711
glaucopus	*glaucopus*	706	712
calochrous	*calochrous*	707	713
caerulescens var. *caesio-cyaneus*	*caesio-cyanus*	708	721
caerulescens	*caerulescens*	709	722
purpurascens	*purpurascens*	710	723
purpurascens	*purpurascens*	711	724
purpurascens var.	*subpurpurascens*	712	725
xanthophyllus	*dibaphus* var. *xanthophyllus*	713	753
turbinatus	*turbinatus*	714	714
—	—	715	715
fulgens	*fulgens*	716	716
fulmineus	*fulmineus*	717	717
orichalceus	*orichalceus*	718	754
prasinus	*prasinus*	719	735
atro-virens	*atro-virens*	720	736
?	*scaurus*	721	755
glaucopus?	—	722	849
cumatilis	*cumatilis*	723	726
emollitus	*emollitus*	724	727
cristallinus	*crystalinus*	725	728
decoloratus	*decoloratus*	726	729
decolorans	*decolorans*	727	730
porphyropus	*porphyropus*	728	731
croceo-caeruleus	*croceo-caeruleus*	729	732
?	—	730	733
?	*papulosus*	731	718
?	—	732	737
collinitus	*collinitus*	733	738
mucosus	*mucosus*	734	739
collinitus	*collinitus*	735	740
elatior	*elatior*	736	741

No. of bound volume	No. printed on Plate	Cooke			Quélet
737	742	*Cortinarius (Myxacium) elatior*			
738	734	—	—	*grallipes*	*sebaceus*
739	767	—	—	*livido-ochraceus*	*albo-cyaneus* décoloré
740	768	—	—	*salor*	—
741	743	—	—	*delibutus*	—
742	831	—	—	*stillatitius*	—
743	744	—	—	*vibratilis*	—
744	769	—	—	*pluvius*	—
745	745	—	*(Inoloma)*	*argentatus*	—
746	746			— var. *pinetorum*	—
747	770	—	—	*violaceus*	*purpurascens*
748	815	—	—	*muricinus*	
749	747	—	—	*albo-violaceus*	*malè*
750	756	—	—	*malachius*	*glaucopus*
751	771	—	—	*camphoratus*	*malè, varius ?*
752	757	—	—	*traganus*	*malè, amethystinus !*
753	772	—	—	*tophaceus*	—
754	773	—	—	*redimitus*	*fulmineus*
755	774	—	—	*callisteus*	*percomis* ou *triumphans*
756	864	—	—	*callisteus*	*hinnuleus*
757	758	—	—	*Bulliardi*	*malè*
758	759	—	—	*vinosus*	*purpurascens*
759	760	—	—	*bolaris*	—
760	761	—	—	*pholideus*	—
761	762	—	—	*sublanatus*	—
762	763	—	—	*arenatus*	—
763	764	—	—	*penicillatus*	—
764	775	—	*(Dermocybe)*	*ochroleucus*	—
765	816	—	—	*decumbens*	*causticus*
		—	—	*diabolicus*	*rigens*
766	783	—	—	*tabularis*	*decoloratus*
767	784	—	—	*camurus*	*hinnuleus*
768	765	—	—	*caninus*	*delibutus*
769	817	—	—	*myrtillinus*	*benè !!*
770	766	—	—	*azureus*	*infractus*
771	748	—	—	*albo-cyaneus*	*sebaceus*
772	776	—	—	*anomalus*	*imbutus* décoloré ou *decoloratus*
773	850	—	—	*lepidopus*	*caninus*
774	785	—	—	*miltinus*	—
		—	—	*cinnabarinus*	—
775	786	—	—	*sanguineus*	*malè*
776	787	—	—	*anthracinus*	
		—	—	*orellanus*	*brunneofulvus*
777	777	—	—	*cinnamomeus*	—
778	778	—	—	— var.	—
779	779	—	—	— var. *semi-sanguineus*	—
780	780	—	—	— var. *croceus*	—
		—	—	— var. *croceo-conus*	—
781	851	—	—	*uliginosus*	—
782	781	—	—	*infucatus*	—
783	749	—	—	*cotoneus*	—
784	832	—	—	*subnotatus*	*raphanoides*
785	750	—	—	*valgus*	*raphanoides*
786	833	—	—	*raphanoides*	*venetus*, vetustior
		—	—	*venetus*	
787	788	—	*(Telamonia)*	*macropus*	*evernius*

MAIRE	REA	No. of bound volume	No. printed on Plate
elatior	*elatior*	737	742
?	—	738	734
?	*livido-ochraceus*	739	767
salor	—	740	768
illibatus (spore allongée)	*delibutus* typical	741	743
stillatitius	—	742	831
vibratilis	*vibratilis*	743	744
—	*pluvius* typical	744	769
argentatus	*argentatus*	745	745
argentatus	*argentatus* var. *pinetorum*	746	746
purpurascens ?	*purpurascens*	747	770
muricinus	—	748	815
argentatus ?	*albo-violaceus*	749	747
?	—	750	756
?	—	751	771
traganus	*traganus*	752	757
tophaceus	*tophaceus*	753	772
?	—	754	773
?	—	755	774
hinnuleus	—	756	864
Bulliardii ?	*Bulliardii* poor	757	758
purpurascens ?	*vinosus*	758	759
bolaris	*bolaris*	759	760
pholideus	*pholideus*	760	761
?	*pholideus*	761	762
?	*pholideus*	762	763
penicillatus	—	763	764
ochroleucus	*ochroleucus*	764	775
cristallinus?	—	765	816
rigens			
decoloratus	—	766	783
hinnuleus ?	—	767	784
certe non delibutus; caninus ? sporae differunt	*caninus* poor	768	765
myrtillinus	*myrtillinus*	769	817
infractus pâle?	—	770	766
sebaceus?	—	771	748
?	*anomalus*	772	776
caninus	*lepidopus*	773	850
phoeniceus (= *miltinus* Quél.)	*phoeniceus*	774	785
cinnabarinus	*cinnabarinus*		
plutôt la teinte de *cinnabarinus*	? *cinnabarinus*	775	786
phoeniceus ?	*anthracinus* poor	776	787
orellanus Fr. non Quél.	*orellanus*		
cinnamomeus	*cinnamomeus*	777	777
cinnamomeus	*cinnamomeus*	778	778
semisanguineus	*semi-sanguineus*	779	779
cinnamomeus var. *croceus*	var. *croceus*	780	780
cinnamomeus var. *croceoconus*	var. *croceoconus*		
cinnamomeus var. *uliginosus*	*uliginosus*	781	851
—	—	782	781
cotoneus	*sublanatus*	783	749
raphanoides	*subnotatus*	784	832
raphanoides	—	785	750
venetus	—	786	833
venetus	*venetus*		
evernius ?	—	787	788

No. of bound volume	No. printed on Plate	Cooke			Quélet
788	800	*Cortinarius (Telamonia) laniger*			*bivelus*
789	852	—	—	*bivelus*	
790	834	—	—	*bulbosus*	*trop rouge*
791	818	—	—	*urbicus*	—
792	819	—	—	*licinipes* var. *robustior*	*glandicolor*
793	865	—	—	*microcyclus*	*glandicolor*
794	801	—	—	*torvus*	*impennis* !
795	853	—	—	*impennis*	—
796	820	—	—	*scutulatus*	—
		—	—	*quadricolor*	*albo-cyaneus*
797	821	—	—	*evernius*	*anomalus*
798	866	—	—	*evernius*	*elatior*
799	867	—	—	*quadricolor*	*elatior*, gracilis
800	802	—	—	*armillatus*	*haematochelis*
801	803	—	—	*haematochelis*	
802	804	—	—	*limonius*	*Tricholoma equestre* ?
		—	—	*helvolus*	*hinnuleus*
803	805	—	—	*hinnuleus*	—
804	806	—	—	*gentilis*	mal copié de Fries
805	836	—	—	*helvelloïdes*	*obtusus* var. *gracilis*
806	835	—	—	*rubellus*	*orellanus*, major
807	822	—	—	*bovinus*	—
808	837	—	—	*nitrosus*	*infractus*, vetustior
809	823	—	—	*injucundus*	*largus* ou *varius*
810	854	—	—	*brunneus*	*impennis*
811	868	—	—	*brunneus*	—
812	789	—	—	*glandicolor*	*milvinus* ?
813	855	—	—	*punctatus*	{ *hinnuleus* / *obtusus*
814	790	—	—	*triformis* var. *Schaefferi*	*claricolor*
815	869	—	—	*biformis*	*hinnuleus*
816	838	—	—	*periscelis*	copié de Fries
817	824	—	—	*flexipes*	—
		—	—	*flabellus*	*paleaceus* (non vert)
818	839	—	—	*psammocephalus*	
		—	—	*ileopodius*	*hinnuleus*
819	807	—	—	*incisus* var. *B.*	*leucopus* ?
820	825	—	—	*hemitrichus*	—
821	840	—	—	*stemmatus*	*hinnuleus*
		—	—	*Cookei*	malè, spore fauve non jaune
822	791	—	—	*rigidus*	*milvinus*
823	826	—	—	*paleaceus*	—
824	792	— (Hydrocybe)		*firmus*	—
825	808	—	—	*subferrugineus*	*caninus*
826	793	—	—	*armeniacus*	—
827	856	—	—	*damascenus*	?
828	827	—	—	*privignus*	*anomalus*
829	809	—	—	*duracinus* Fries ?	*armeniacus* ?
830	841	—	—	*illuminus*	—
831	857	—	—	*tortuosus*	—
832	810	—	—	*dilutus*	*rigens*
833	828	—	—	*saturninus*	—
834	870	—	—	*imbutus*	*impennis*
835	842	—	—	*castaneus*	malè
836	871	—	—	*bicolor*	*albo-cyaneus*
837	794	—	—	*balaustinus*	*brunneo-fulvus*

Maire	Rea	No. of bound volume	No. printed on Plate
bivelus	—	788	800
bivelus	—	789	852
?	*bulbosus*	790	834
?	—	791	818
?	—	792	819
glandicolor	—	793	865
torvus Fr. non Quél.	*torvus*	794	801
idem ?	*impennis*	795	853
scutulatus	*scutulatus*	796	820
bicolor	*bicolor*		
bicolor	*bicolor*	797	821
evernius?	*elatior*	798	866
?	*quadricolor*	799	867
armillatus	*armillatus*	800	802
armillatus forma	*armillatus*	801	803
? peut-être un *Flammula* ou *Pholiota*	—	802	804
hinnuleus	*helvolus*		
hinnuleus	*hinnuleus*	803	805
gentilis	*gentilis*	804	806
saniosus ?	—	805	836
?	*orellanus*	806	835
?	*bovinus*	807	822
?	—	808	837
largus ?	—	809	823
torvus Fr. non Quél.?	*brunneus*	810	854
brunneus	*brunneus*	811	868
?	*glandicolor*	812	789
?	—	813	855
obtusus ? } *claricolor* ?	—	814	790
?	—	815	869
—	*periscelis*	816	838
flexipes?	*flexipes*	817	824
?			
psammocephalus	*psammocephalus*	818	839
hinnuleus f. *gracilis*	—		
?	*incisus*	819	807
hemitrichus	*hemitrichus*	820	825
?	—	821	840
Cookei	—		
?	*rigidus*	822	791
paleaceus=*flexipes* Ricken	*paleaceus*	823	826
—	—	824	792
subferrugineus	*subferrugineus*	825	808
armeniacus	*armeniacus*	826	793
?	—	827	856
?	—	828	827
duracinus?	*duracinus*	829	809
?	—	830	841
?	—	831	857
rigens ?	—	832	810
saturninus	*saturninus*, pileus darker than usual	833	828
?	—	834	870
{ *castaneus* { ? figures inférieures }	*castaneus*, fairly typical	835	842
bicolor	*bicolor* typical	836	871
balaustinus, trop rouge	*balaustinus*, too dark	837	794

No. of bound volume	No. printed on Plate	COOKE	QUÉLET
838	795	Cortinarius (Hydrocybe) colus	obtusus, major
839	829	—— —— isabellinus	——
840	782	—— —— renidens	
841	796	—— —— uraceus	——
842	797	—— —— jubarinus	hinnuleus
843	858	—— —— pateriformis var. major	duracinus ?
844	859	—— —— unimodus	erythrinus
845	811	—— —— dolobratus	armeniacus !
846	812	—— —— rigens	——
847	813	—— —— Krombholzii	——
848	843	—— —— Reedii	milvinus
		—— —— leucopus	
849	830	—— —— scandens	leucopus
850	798	—— —— erythrinus	decipiens
		—— —— decipiens	hinnuleus
851	844	—— —— germanus	malè
852	845	—— —— obtusus	
		—— —— acutus	malè
853	846	—— —— Junghuhnii	orellanus
		—— —— milvinus	malè, pas jaune
854	860	—— —— depressus	duracinus
855	814	—— —— fasciatus	malè, stemmatus non jaune
856	879	Gomphidius glutinosus	——
857	880	—— roseus	malè, plus rouge
858	881	—— viscidus	——
859	882	—— maculatus (var.)	——
860	883	—— gracilis	——
861	872	Paxillus (Lepista) lepista	——
862	874	—— —— panaeolus	helomorphus
		—— —— orcelloides	mundulus
863	873	—— —— extenuatus	geotropus, forme
864	861	—— —— lividus	Trich. cinerascens
865	862	—— —— revolutus	H. subradiatus var. lacmus
866	884	—— —— paradoxus	——
867	875	—— (Tapinia) involutus	malè, trop jaune
868	929	—— —— leptopus	trop jaune
869	876	—— —— atrotomentosus	malè
870	877	—— —— crassus	vinosus Bull. = leptopus
871	878	—— —— panuoïdes	malè
872	885	Hygrophorus (Limacium) chrysodon	! benè
873	886	—— —— eburneus	——
874	887	—— —— cossus	——
875	895	—— —— pulverulentus	malè, non le mien
		—— —— penarius	malè
876	888	—— —— erubescens	——
877	911	—— —— pudorinus	——
878	889	—— —— glutinifer	olivaceo-albus, malè
879	896	—— —— arbustivus	——
		—— —— aureus	
880	912	—— —— discoideus	malè, potius nitidus
881	897	Hygrophorus (Limacium) limacinus	malè, non jaune olive
882	890	—— —— olivaceo-albus	malè, gracilis, vetustior
883	891	—— —— hypothejus	Russula nauseosa
884	898	—— —— cerasinus	——
885	899	—— —— fusco-albus	Lactarius trivialis

MAIRE	REA	No. of bound volume	No. printed on Plate
?	—	838	795
?	—	839	829
renidens, trop pâle	—	840	782
uraceus	*uraceus*	841	796
?	—	842	797
duracinus ?	—	843	858
erythrinus	*erythrinus*	844	859
candelaris ?	*dolobratus*	845	811
duracinus ?	*duracinus*	846	812
?	*Krombholzii*	847	813
Inocybe sp.	—	848	843
leucopus	*leucopus*		
?		849	830
erythrinus	*erythrinus*	850	798
?	*decipiens*		
?	*germanus*	851	844
obtusus	*obtusus*	852	845
acutus ?	*acutus*		
concinnus Karst. (= *orellanus* Quél. non Fr.)	—	853	846
?			
duracinus	—	854	860
?	*fasciatus*	855	814
glutinosus	*viscidus* typical	856	879
roseus	*roseus*	857	880
viscidus	*viscidus*	858	881
maculatus	*maculatus*	859	882
gracilis	*gracilis*	860	883
?	—	861	872
Ripartites Tricholoma var. *helomorpha*	*panaeolus* typical	862	874
mundulus	*orcelloides* typical		
Clitocybe amara Fr.	—	863	873
Clit. fumosa Fr.= *cinerascens* Quél.	*lividus*	864	861
Hygr. pratensis var. *cinereus* ? ou *H. flavipes* Britz. à cause des spores rondes	—	865	862
Phylloporus rhodoxanthus	*paradoxus* typical	866	884
involutus, trop jaune	*involutus* poor	867	875
non ! spores differentes	—	868	929
atrotomentosus, trop rouge	*atrotomentosus*	869	876
? *Phylloporus rhodoxanthus*, vetustus		870	877
panuoïdes	*panuoïdes*	871	878
chrysodon	*chrysodon*	872	885
eburneus	*eburneus*	873	886
eburneus var. *cossus*	*cossus*	874	887
niveus, forme à pied rosé ?	—	875	895
penarius	*penarius*		
erubescens	*erubescens*	876	888
pudorinus (forma fagetorum)	*pudorinus*	877	911
olivaceo-albus ?	—	878	889
arbustivus	*arbustivus*	879	896
aureus	*aureus*		
discoideus Fr., Lange = *nitidus* Quél. non Fr.	*discoideus*	880	912
olivaceo-albus ?	—	881	897
olivaceo-albus, peu typique	*olivaceo-albus*, thin form	882	890
hypothejus, trop rougeâtre	*hypothejus*	883	891
cerasinus	*cerasinus*	884	898
fusco-albus ?	*fusco-albus*	885	899

No. of bound volume	No. printed on Plate	COOKE		QUÉLET
886	913	*Hygrophorus (Limacium) agathosmus*		malè, gris, *olivaceo-albus*
887	914	—	— *mesotephrus*	malè, *discoideus*
888	915	—	— *livido-albus*	*streptopus*
889	916	— *(Camarophyllus) caprinus*		?
890	930	—	— *leporinus*	
891	931	—	— *nemoreus*	*Cortinarius armeniacus*
892	917	—	— *pratensis*	—
893	932	—	— var. *pallidus*	
		—	— var. *cinereus*	malè
894	892	—	— *virgineus*	
895	893	—	— var. *roseipes*	*niveus*, major
896	900	—	— *niveus*	*gracilis*
		—	— *russo-coriaceus*	*virgineus*, minor
897	901	—	— *ventricosus*	*gliocyclus*
898	933	—	— *fornicatus*	*obrusseus*, pâle
899	902	—	— *distans*	*clivalis*
900	934	—	— *Clarkii*	
		—	— *ovinus*	malè
901	918	—	— *metapodius*	benè
902	935	—	— *subradiatus*	
		—	— var. *lacmus*	—
903	919	—	— *irrigatus*	
904	903	— *(Hygrocybe) Colemannianus*		*spadiceus* forme
		—	— *foetens*	*Omphalia atropuncta*, vieux
905	937	—	— *sciophanus*	
		—	— *mucronellus*	*conicus*, gracilis
906	938	—	— *laetus*	
907	936	—	— *Houghtoni*	*laetus*! forme
908	904	—	— *vitellinus*	—
		—	— *ceraceus*	
909	920	—	— *coccineus*	*puniceus*
910	921	—	— *miniatus*	*coccineus*
		—	— *turundus* var. *mollis*	
911	905	—	— *Wynniae*	*Omphalia bibula* var. *virens*
		—	— *micaceus*	*O. umbellifera* var. *flava*
912	922	—	— *puniceus*	—
913	906	—	— *obrusseus*	
914	907	—	— *intermedius*	*obrusseus*
915	908	—	— *conicus*	—
916	894	—	— *calyptraeformis*	
917	923	—	— var. *niveus*	*amoenus* var. *alba*
918	909	—	— *chlorophanus*	*coccineus* décoloré
919	910	—	— *psittacinus*	—
920	924	—	— *unguinosus*	
921	925	—	— *nitratus*	*caprinus* pâle
922	971	*Lactarius (Piperites) scrobiculatus*		
923	972	—	— *torminosus*	malè
924	973	—	— *cilicioïdes*	*scrobiculatus*, malè
925	987	—	— *turpis*	
926	1003	—	— *controversus*	— (*vetustus*)
927	974	—	— *pubescens*	*torminosus* (*vetustior*)
928	1083	—	— *aspideus*	
929	975	—	— *insulsus*	—
930	1084	—	— *utilis*	*Russula foetens* ?
931	988	—	— *blennius*	
932	989	—	— *hysginus*	malè
933	976	—	— *trivialis*	*zonarius* (*vetustus*)
934	990	—	— *circellatus*	

Maire	Rea	No. of bound volume	No. printed on Plate
? plutôt *olivaceo-albus*	—	886	913
leucophaeus (= *discoideus* Quél.non Fr.)	*discoideus* typical	887	914
? ?	*livido-albus*	888	915
Camarophyllus Fr. = *caprinus*	*camarophyllus*	889	916
?	—	890	930
nemoreus, peu typique	*leporinus*	891	931
pratensis	*pratensis*	892	917
pratensis var. *pallidus*	*pratensis* var. *pallidus*	893	932
pratensis var. *cinereus*	*pratensis* var. *cinereus*		
virgineus	*virgineus*	894	892
virgineus f. *roseipes* (= *clivalis* Q.,teste Patouillard)	*virgineus* var. *roseipes*	895	893
virgineus var. *niveus*	*niveus*	896	900
virgineus var. *russo-coriaceus*	*russo-coriaceus*		
forme de *virgineus*	—	897	901
plutôt *Trich. sejunctum* grêle	*clivalis*	898	933
?	—	899	902
?	*irrigatus*	900	934
ovinus	*ovinus*		
metapodius	*metapodius*	901	918
—	*subradiatus*	902	935
	lacmus		
irrigatus	*irrigatus*	903	919
Colemannianus	*Colemannianus*	904	903
O. *atropuncta*	*foetens* typical		
sciophanoides Rea	*sciophanoides* Rea	905	937
?	*mucronella*		
laetus	*laetus*	906	938
laetus	*laetus*	907	936
vitellinus	*vitellinus*	908	904
ceraceus	*ceraceus*		
puniceus	*coccineus*, typical with yellow base	909	920
coccineus	*miniatus*	910	921
turundus var. *mollis*	*turundus* var. *mollis*		
O. *Wynniae*	*Wynniae*	911	905
pas O. *umbellifera* à cause des spores	*micaceus*		
puniceus	*puniceus*	912	922
obrusseus	*obrusseus*	913	906
obrusseus	*obrusseus*	914	907
conicus	*conicus*	915	908
calyptriformis	*calyptraeformis*	916	894
calyptriformis var. *niveus*	*calyptraeformis* var. *niveus*	917	923
chlorophanus	*chlorophanus*	918	909
psittacinus	*psittacinus*	919	910
unguinosus	*unguinosus*	920	924
nitratus ?	*nitratus*	921	925
scrobiculatus	*scrobiculatus*	922	971
torminosus	*torminosus*	923	972
?	*cilicioides*, pale form	924	973
turpis	*turpis*	925	987
controversus	*controversus*	926	1003
torminosus	*pubescens*	927	974
aspideus Fr. (*flavidus* Boud.)	*uvidus*	928	1083
insulsus	*insulsus*	929	975
Russ. delica ?	—	930	1084
blennius	*blennius*	931	988
hysginus ?	*hysginus*	932	989
insulsus, vieux ?	—	933	976
	—	934	990

No. of bound volume	No. printed on Plate	Cooke	Quélet
935	991	*Lactarius (Piperites) uvidus*	*violascens* !
936	992	— — *flexuosus*	*uvidus* (vetustus)
937	993	— — *pyrogalus*	
938	1004	— — *squalidus*	
		— — *scoticus*	*argematus* ou *Russ. Raoultii*
939	977	— — *capsicum*	*rufus*
940	984	— — *chrysorrheus*	
941	1005	— — *acris*	*picinus* Fr.
942	1006	— — *umbrinus*	*Russula fusca* Q.
943	978	— — *pargamenus*	*piperatus*
944	979	— — *piperatus*	
945	980	— — *vellereus*	
946	981	— — *exsuccus*	*Russula delica*
947	982	— (Dapetes) *deliciosus*	
948	1007	— (Russularia) *pallidus*	
949	983	— — *quietus*	*rufus*
950	1099	— — *aurantiacus*	
951	1008	— — *cremor* var. *pauper*	*tithymalinus* ?
952	1009	— — *vietus*	
		— — *cyathula*	non, *argematus* ou *trivialis*
953	1085	— — *cyathula*	non! *glyciosmus* var. *lilacinus*
954	985	— — *rufus*	
955	994	— — *helvus*	non! trop rouge
956	1010	— — *tomentosus*	*deliciosus* ou *tithymalinus*
957	995	— — *mammosus* var. *monstrosus*	
958	1011	— — *glyciosmus*	?
959	996	— — *fuliginosus*	*azonites* ou *picinus*
960	997	— — *picinus*	
961	998	— *lilacinus*	malè
		— *spinosulus* var. *violaceus*	malè
962	999	— *volemus*	
963	1000	— *ichoratus*	espèce douteuse, forme de *volemus*
964	1012	— *serifluus*	
965	1001	— *mitissimus*	
966	1002	— *subdulcis*	pas assez rouge
967	1013	— *camphoratus*	*subdulcis*
		— *cimicarius*	*camphoratus*
968	986	— *subumbonatus*	*subdulcis*, forme approchant *tabidus*
		— *minimus*	*subdulcis* var.
969	1014	— *obnubilis*	Hygr. *hypothejus*
		— *obliquus*	*trivialis*, forme
970	1015	— *nigricans*	
971	1016	— *albo-nigra*	*adusta*, forme
972	1051	— *adusta*	{ *adusta* var. *citrina* } *olivascens*
973	1017	— *densifolia*	*nigricans* ?
974	1067	— *semicrema*	*ochroleuca*
975	1068	— *delica*	var. *albata*
976	1018	— *mustelina*	malè
977	1035	*Russula olivascens*	
978	1036	— *furcata*	*cyanoxantha*, vetustior
979	1086	— — var. *pictipes*	*cyanoxantha*, forme inconnue
980	1100	— — var. *ochroviridis*	*cyanoxantha*, forme inconnue
981	1019	— *sanguinea*	?
982	1020	— *rosacea*	non, *lepida*
983	1069	— *maculata*	non! rien de commun; R. *violacea* Q. forme obèse

Maire	Rea	No. of bound volume	No. printed on Plate
uvidus	*uvidus* typical	935	991
?	—	936	992
pyrogalus	*pyrogalus*	937	993
?	—	938	1004
rufus ?	—	939	977
chrysorrheus	*chrysorrheus*	940	984
picinus	—	941	1005
?	—	942	1006
piperatus	*piperatus* var. *pergamenus*	943	978
piperatus	*piperatus* typical	944	979
vellereus	*vellereus*	945	980
R. *delica* var. *glaucophylla*	R. *chloroides*	946	981
deliciosus	*deliciosus*	947	982
pallidus	*pallidus*	948	1007
quietus, trop foncé	*quietus*	949	983
aurantiacus	*aurantiacus*	950	1099
état de *volemus* ?	—	951	1008
vietus ?	*vietus* typical	952	1009
?			
lilacinus ?	—	953	1085
rufus	*rufus*	954	985
paraît un vieux *torminosus*	—	955	994
torminosus ?	—	956	1010
——	—	957	995
glyciosmus, peu typique	*glyciosmus*	958	1011
picinus	*fuliginosus*	959	996
picinus	*picinus*	960	997
lilacinus	*lilacinus*	961	998
spinosulus var. *violaceus*	*spinosulus* var.		
volemus	*volemus*	962	999
volemus	—	963	1000
serifluus, trop violet	*serifluus*	964	1012
mitissimus	*mitissimus*	965	1001
quietus ? peu typique	—	966	1002
camphoratus	*camphoratus*	967	1013
camphoratus var. *obnubilus*	*cimicarius*		
camphoratus f. *subumbonatus*	—	968	986
?	—		
Hygr. *hypothejus*	—	969	1014
?	—		
nigricans	*nigricans*	970	1015
adusta var. *albo-nigra*	*adusta* var. *albo-nigra*	971	1016
adusta	*adusta*	972	1051
densifolia	*densifolia*	973	1017
?	—	974	1067
delica	—	975	1068
mustelina ?	*mustelina*	976	1018
alutacea var. *olivascens* ?	*alutacea* var. *olivascens*	977	1035
cyanoxantha	—	978	1036
cyanoxantha forme	*furcata* var. *pictipes*	979	1086
cyanoxantha, vieux	—	980	1100
sanguinea	*sanguinea*	981	1019
sanguinea forme	*sanguinea*	982	1020
depallens forme	*atropurpurea*	983	1069

No. of bound volume	No. printed on Plate	COOKE	QUÉLET
984	1037	*Russula sardonia*	non! *decolorans* ou *olivascens* var. *citrina*
985	1021	—— *depallens*	malè! *amoena* ou *depallens* var. *vinosa*
986	1022	—— *purpurea*	*nitida* ou *palumbina*, spore ?
987	1052	—— *coerulea*	
988	1023	—— *drimeia*	*Queletii*
989	1070	—— *lactea*	
990	1071	—— —— var. *incarnata*	——
991	1039	—— *virescens*	non! pas vert olive
992	1024	—— *cutefracta*	——
993	1040	—— *cutefracta*	——
994	1072	—— *lepida*	forme
995	1073	—— *lepida* var.	——
996	1025	—— *rubra*	*sanguinea*
997	1087	—— *rubra* Fries (?) var. *sapida*	——
998	1026	—— *Linnaei*	
999	1053	—— *xerampelina*	? *nitida*
1000	1074	—— *xerampelina*	? inconnu
1001	1041	—— *olivacea*	!
1002	1075	—— *vesca*	*depallens* var. *vinosa* ou *cyanoxantha*
1003	1042	—— *du Portii*	*cyanoxantha*
		—— *serotina*	——
1004	1054	—— *lilacea*	——
1005	1088	—— *azurea*	——
1006	1043	—— *cyanoxantha*	——
1007	1076	—— *cyanoxantha*	——
1008	1077	—— *cyanoxantha* var.	——
1009	1044	—— *heterophylla*	*graminicolor*
1010	1045	—— *heterophylla*	*foetens*
1011	1089	—— *galochroa*	——
1012	1055	—— *consobrina*	——
1013	1056	—— —— var. *intermedia*	——
1014	1057	—— —— var. *sororia*	——
1015	1046	—— *foetens*	——
1016	1047	—— *subfoetens*	? *foetens*, minor
1017	1058	—— *fellea*	——
1018	1027	—— *elegans*	*delica* ?
1019	1028	—— *Queletii*	——
1020	1029	—— *expallens*	*sanguinea*, minor
1021	1030	—— *emetica*	*rosacea*
1022	1031	—— *Clusii*	?
1023	1059	—— *fallax*	*lilacea* Q.
1024	1101	—— *pectinata*	*foetens*, minor
1025	1049	—— *ochroleuca*	
1026	1038	—— *granulosa*	*ochroleuca*
1027	1090	—— *aeruginea*	
1028	1091	—— *fragilis*	——
1029	1060	—— —— var. *violacea*	aspect de *lilacea*
		—— —— var. *niveus*	——
1030	1048	—— *fingibilis*	*ochroleuca*
1031	1078	—— *citrina* Gillet	*lutea*
1032	1032	—— *punctata* var. *leucopus*	*nitida* forme

MAIRE	REA	No. of bound volume	No. printed on Plate
Queletii var. *flavovirens* ?	—	984	1037
depallens = *atropurpurea* Krombh.	*atropurpurea* var. *depallens*	985	1021
depallens ?	*atropurpurea* var. *depallens*	986	1022
caerulea	*caerulea*	987	1052
sardonia Fr. non Bres.	*drimeia* = *sardonia* Fr.	988	1023
lactea	*lactea*	989	1070
lactea var. *incarnata*	*incarnata*	990	1071
{ *virescens* } { ? }	*virescens*	991	1039
cutifracta	*cutifracta*	992	1024
cutifracta	*cutifracta*	993	1040
{ *rosea* Quél. } { *lepida* }	*lepida*	994	1072
{ *xerampelina* jeune } { *rosea* Quél. }	*lepida*	995	1073
atrorubens Quél.	*atropurpurea* typical	996	1025
melliolens forme foncée?	*atropurpurea* typical	997	1087
xerampelina var. *erythropoda* ?	*Linnaei* typical	998	1026
grisea ?	—	999	1053
{ *xerampelina* } { ? fig. inférieure }	*xerampelina* } *fusca* }	1000	1074
alutacea forme	*olivacea* typical	1001	1041
cyanoxantha forme ?	*vesca*	1002	1075
xerampelina var.	—	1003	1042
serotina	*serotina*		
vesca (sensu Bres.) ? ou *lilacea* géant	*lilacea*	1004	1054
azurea	*azurea*	1005	1088
cyanoxantha	*cyanoxantha*	1006	1043
idem .	*cyanoxantha*	1007	1076
grisea Bres. ?	*cyanoxantha*	1008	1077
heterophylla	*heterophylla*	1009	1044
heterophylla forme	*heterophylla*	1010	1045
galochroa	*galochroa*	1011	1089
consobrina	*consobrina*	1012	1055
pectinata var.	*consobrina* var. *sororia*	1013	1056
idem	*pectinata*	1014	1057
foetens	*foetens*	1015	1046
subfoetens sensu Maire = *farinipes* Romell	*laurocerasi*	1016	1047
fellea	*fellea*	1017	1058
elegans	—	1018	1027
Queletii	*Queletii*	1019	1028
Queletii forme	*drimeia*	1020	1029
rosacea Quél. non Fr.	*emetica*	1021	1030
emetica	*emetica* var. *Clusii*	1022	1031
fallax = *olivaceoviolascens* Gill.	*emetica* var. *fallax*	1023	1059
pectinata ?	*pectinata*	1024	1101
ochroleuca	*ochroleuca*	1025	1049
?	*ochroleuca* var. *granulosa*	1026	1038
aeruginea ? ou *cyanoxantha* forme	*graminicolor*	1027	1090
fragilis	*fragilis* typical	1028	1091
violacea Quél. ?	*violacea*	1029	1060
fragilis var. *nivea*	*fragilis* var. *nivea*		
ochroleuca ?	*ochroleuca*	1030	1048
citrina Gill. non Quél.	*citrina*	1031	1078
nauseosa Fr. forme = *Turci* Bres. sensu Maire	—	1032	1032

No. of bound volume	No. printed on Plate	Cooke	Quélet
1033	1033	*Russula veternosa*	
1034	1092	— *veternosa*	*chamaeleontina* ? spore ?
1035	1081	— *roseipes* var.	*xerampelina, gracilis,* spore ?
1036	1034	— *integra*	
1037	1093	— *integra*	*fusca* ?
1038	1094	— — var. *alba*	*olivascens* var. *citrina*, aspect de *foetens*
1039	1079	— *decolorans*	!
1040	1061	— *Barlae*	?
1041	1080	— *aurata*	?
1042	1062	— *nitida* var.	*Barlae*
1043	1063	— *nitida*	
1044	1095	— *pulchralis*	*puellaris*
		— *nitida* var. *cupraea*	*fusca,* minor
1045	1064	— *armeniaca*	*chamaeleontina*
1046	1065	— *puellaris*	
1047	1066	— *puellaris* var.	*nitida*
1048	1096	— *alutacea*	
1049	1097	— *alutacea*	*fusca* ?
1050	1050	— *ochracea*	
1051	1082	— *lutea*	
1052	1147	— *nauseosa*	
1053	1102	— *nauseosa* var. *flavida*	*lutea*
		— *vitellina*	*ochracea*
1054	1098	— *chameleontina*	au coin supérieur droit : *lilacea* Q.
1055	1103	*Cantharellus cibarius*	
1056	1131	— *cibarius* var. *rufipes*	*cibarius,* vetustus .
		— *Friesii*	*cibarius*
1057	1104	— *aurantiacus*	
1058	1106	— *Brownii*	*albidus*
		— *umbonatus*	
1059	1105	— *carbonarius*	
1060	1107	— *albidus*	*cibarius* var. *albescens*
		— *Houghtoni*	*Marasmius incarnatus*
1061	1108	— *tubaeformis*	?
1062	1109	— *infundibuliformis*	?
1063	1110	— *cinereus*	*cornucopioides,* forme
		— *cupulatus*	? ?
1064	1111	— *leucophaeus*	*carbonarius,* forme
		— *Stevensoni*	*albidus*
1065	1115	— *muscigenus*	malè, il est cendré
		— *glaucus*	
1066	1112	— *retirugis*	
		— *lobatus*	non, gris
1067	1132	*Nyctalis caliginosa*	*parasitica*
		— *asterophora*	
1068	1113	— *parasitica*	
1069	1116	*Marasmius urens*	
1070	1117	— *peronatus*	
1071	1133	— *porreus*	*foetidus* ?
1072	1118	— *oreades*	

Maire	Rea	No. of bound volume	No. printed on Plate
veternosa forme	*veternosa*	1033	1033
veternosa	*veternosa* var.	1034	1092
roseipes ?	*roseipes*	1035	1081
Romellii Maire ?	*Romellii*	1036	1034
integra Fr. ?	*integra*	1037	1093
Romellii pâle?	*Romellii*	1038	1094
decolorans	*decolorans*	1039	1079
xerampelina var. ?	*xerampelina*	1040	1061
aurata	*aurata*	1041	1080
?	—	1042	1062
{ *nitida* ? { *nauseosa* Fr. ?	—}	1043	1063
puellaris ?	*nitida* var. *pulchralis*	1044	1095
nitida	*nitida* typical		
chamaeleontina	*lutea* var. *armeniaca*	1045	1064
puellaris	*puellaris*	1046	1065
xerampelina forma gracilis?	*puellaris* var. *intensior*	1047	1066
alutacea	*alutacea*	1048	1096
xerampelina	*xerampelina*	1049	1097
?	—	1050	1050
lutea	*lutea*	1051	1082
nauseosa Fr. (= *Turci* Bres.)	—	1052	1147
lutea ? ou forme pâle de *nauseosa*	—	1053	1102
lutea forma?	*lutea* var. *vitellina*		

formes voisines de *chamaeleontina*:
  en haut à droite: *lilacea* Quél.
les 4 autres supérieures et les deux
  inférieures: *ochrorosea* Maire inédit;
  les 3 du milieu = *R. abietina* Peck
	chamaeleontina	1054	1098

cibarius	*cibarius*	1055	1103
cibarius vieux	*cibarius* var. *rufipes*	1056	1131
cibarius	—		
aurantiacus type et variété	{ *aurantiaca* { *aurantiaca* var. *albida* }	1057	1104
albidus	—	1058	1106
umbonatus	*umbonatus*		
carbonarius	*carbonarius*	1059	1105
aurantiacus, forme décolorée	—	1060	1107
?			
tubaeformis	*tubaeformis*	1061	1108
infundibuliformis	*infundibuliformis*	1062	1109
cornucopioides, forme à hymenium plissé	*cinereus*	1063	1110
?			
carbonarius	—	1064	1111
albidus	—		
?	*muscigenus*	1065	1115
glaucus	*glaucus*		
retirugis	*retirugis*	1066	1112
?	—		
?	—	1067	1132
asterophora	*asterophora* poor		
parasitica	*parasitica*	1068	1113
peronatus, trop foncé	*urens*	1069	1116
peronatus	*peronatus*	1070	1117
?	—	1071	1133
oreades, trop jaune	*oreades*	1072	1118

No. of bound volume	No. printed on Plate	COOKE	QUÉLET
1073	1119	*Marasmius plancus*	*Collybia extuberans*
		—— scorteus	globularis
			non, scorteus ?
1074	1120	—— prasiosmus	fusco-purpureus forme
1075	1121	—— varicosus	Mycena pura
		—— fusco-purpureus	
1076	1122	—— terginus	globularis coloré
		—— archyropus	globularis
1077	1123	—— Wynnei	terginus
		—— erythropus	
1078	1124	—— torquescens	? malè
		—— impudicus	
1079	1125	—— scorodonius	
		—— calopus	Vaillantii
1080	1126	—— Vaillantii	Vaillantii
		—— angulatus	Omph. umbellifera ?
		—— languidus	
1081	1134	—— foetidus	——
		—— cauticinalis	
1082	1127	—— amadelphus	——
		—— candidus	——
		—— ramealis	
1083	1128	—— alliaceus	
		—— cohaerens	fusco-purpureus
1084	1129	—— rotula	
		—— graminum	
		—— androsaceus	?
1085	1130	—— splachnoides	androsaceus
		—— Curreyi	graminum
		—— perforans	malè
1086	1135	—— insititius	malè
		—— Hudsoni	gelidus Q. ?
1087	1136	—— epichloë	caulicinalis
		—— actinophorus	graminum
		—— saccharinus	
1088	1137	—— epiphyllus	saccharinus
		—— polyadelphus	Pleur. cyphellaeformis
		—— spodoleucus	
1089	1138	*Lentinus* tigrinus	——
1090	1139	—— tigrinus	——
		—— Dunalii	
1091	1140	—— lepideus	——
1092	1141	—— —— monstrous form	——
1093	1142	—— cochleatus	potius *flabelliformis* Schaeff.
		—— vulpinus	suaveolens
1094	1143	—— scoticus	——
1095	1148	—— fimbriatus	
		—— flabelliformis	
1096	1149	*Panus* conchatus	flabelliformis
		—— torulosus	flabelliformis
1097	1144	—— stypticus	flabelliformis forme d'hiver
		—— farinaceus	?
		—— patellaris	inconnu
1098	1150	*Cantharellus devexus*	malè
		Xerotus degener	
1099	1114	*Trogia crispa*	——
		Schizophyllum commune	

MAIRE	REA	No. of bound volume	No. printed on Plate
?	—	1073	1119
Wynnei, petite forme pâle	—		
?	—	1074	1120
fusco-purpureus?	*varicosus*	1075	1121
Mycena pura			
terginus	—	1076	1122
?	—		
Wynnei	*globularis* old	1077	1123
lupuletorum	*erythropus* typical		
torquescens	*torquescens*	1078	1124
impudicus	*impudicus*		
scorodonius	—	1079	1125
Vaillantii forma	—		
Vaillantii	*Vaillantii*	1080	1126
Vaillantii forma	—		
?	—		
foetidus	*foetidus* poor	1081	1134
fulvobulbillosus R. Fries, chapeau trop foncé	*cauticinalis* typical		
amadelphus	—	1082	1127
candidus	*candidus*		
ramealis	*ramealis*		
alliaceus	*alliaceus*	1083	1128
?	—		
rotula	*rotula*	1084	1129
graminum?	*graminum*, stem should be bright		
androsaceus	*androsaceus*		
splachnoides	—	1085	1130
graminum?	—		
perforans? trop pâle	*perforans*		
?	*insititius*	1086	1135
Hudsonii	*Hudsonii*		
stipitarius?	—	1087	1136
?	—		
saccharinus	*saccharinus*		
? spores trop petites	*epiphyllus*	1088	1137
Omphalia polyadelpha	*polyadelphus*		
Pleur. cyphellaeformis	—		
tigrinus	*tigrinus*	1089	1138
tigrinus	*tigrinus*	1090	1139
tigrinus	—		
lepideus	*lepideus*	1091	1140
lepideus, anomalie	*lepideus*, form not uncommon	1092	1141
cochleatus, trop rouge	*cochleatus*	1093	1142
Panus rudis?	—		
?	*scoticus*	1094	1143
tigrinus	*fimbriatus*	1095	1148
torulosus?	—		
torulosus	*torulosus*	1096	1149
torulosus	*torulosus*		
stipticus	*stypticus*	1097	1144
?	—		
?	—		
?	var. of *replexus*	1098	1150
?	—		
crispa	*crispa*	1099	1114
commune	*commune*		

No. of bound volume	No. printed on Plate	COOKE	QUÉLET
1100	1145	*Lenzites betulina*	—
		— *flaccida*	—
1101	1146	— *sepiaria*	—
		— *abietina*	*saepiaria*
1102	939	*Agaricus (Amanita) solitarius*	*solitaria* Quél.
1103	1163	— — *rubescens*	—
1104	940	— — *vaginatus* var. *nivalis*	pas de violet
1105	941	— *(Lepiota) Friesii*	malè
1106	1164	— — *emplastrum*	*Am. rubens!* spore anormale, ou forme anormale de *L. rachodes*
1107	1180	— — *hispidus*	—
1108	943	— — *felinus*	—
		— — *micropholis*	*felina, gracilis*
1109	942	— — *cepaestipes* var. *cretaceus*	benè
1110	1179	— — *licmophorus*	*cepaestipes* var. *lutea*
1111	639	— — *citrophyllus*	*cristata* malade, ou *clypeolaria, gracilis*
1112	944	— — *ianthinus*	*cristata, gracilis*
		— — *martialis*	*haematosperma, gracilis*
1113	955	— *(Armillaria) Jasonis*	*Lep. amianthina*
1114	1165	— — *focalis* var. *goliathus*	*Lep. ampla* P.
1115	1181	— — *Citri*	*mellea*, variété
1116	926	— *(Tricholoma) russula*	—
1117	642	— — *variegatus*	—
1118	641	— — *argyraceus* var. *virescens*	—
1119	947	— — *argyraceus* var. *chrysites*	!
1120	945	— — *inodermeus*	*Hygrophorus russula*
1121	1166	— — *tenuiceps*	*cartilagineum* ou *molybdinum*
1122	1151	— — *fallax*	*album* ou *inamoenum*
		— *(Clitocybe) cinerascens*	*expallens*
1123	956	— *(Tricholoma) borealis*	*Entoloma clypeatum*
1124	946	— — *pes-caprae*	*aggregatum*
1125	1182	— — *circumtectus*	*argyraceum?* ou *luridum*
1126	640	— — *duracinus*	*cinerascens*
1127	957	— — *melaleucus* var. *polioleucus*	*grammopodium, minus?*
1128	1183	— *(Clitocybe) opiparus*	*Trich. truncatum* Sch., très bonne figure
1129	644	— — *amplus*	—
1130	645	— — *fumosus*	—
1131	958	— — *subdecastes*	*Hygr. melizeus?* ou *cossus* vieux
1132	643	— — *pergamenus*	*lignatilis*
1133	1184	— — *occultus*	*argyraceum*, ou *virgatum* ou *hordum*
1134	648	— — *monstrosus*	*Hygr. virgineus?*
1135	646	— — *infundibuliformis* var. *membranaceus*	—
1136	647	— — *sinopicus*	—
1137	948	— — *zygophyllus*	*amarella*
1138	949	— *(Collybia) fodiens*	*maculata*

MAIRE	REA	No. of bound volume	No. printed on Plate
betulina	*betulina*	1100	1145
flaccida	*flaccida*		
saepiaria	*saepiaria*	1101	1146
saepiaria, vieux	*abietina*		
echinocephala	*echinocephala*	1102	939
rubescens	*rubescens*	1103	1163
vaginata var. *nivalis*	*nivalis*	1104	940
Friesii	*Friesii*	1105	941
rhacodes	*rhacodes*	1106	1164
hispida	*hispida*	1107	1180
felina	*felina*, large form	1108	943
?	*micropholis*		
cepaestipes var. *cretaceus*	var. *cretaceus*	1109	942
lutea	*licmophora*	1110	1179
fig. inf. *citrophylla*	*citrophylla*	1111	639
lilacea Bres.?	—	1112	944
?	—		
amianthina	*amianthina*	1113	955
Amanita spissa forme	—	1114	1165
mellea forme	*mellea* var.	1115	1181
Hygrophorus Russula	*Hygr. Russula*	1116	926
—	*variegatum*	1117	642
scalpturatum forma	*argyraceum* var.	1118	641
idem	*argyraceum* var.	1119	947
Hygr. Russula? ou forme stérile de *Inocybe piriodora*	*inodermeum*, a good rare species	1120	945
Coll. platyphylla forma?	*aggregatum*	1121	1166
?	—	1122	1151
?	*cyathiformis*, from stem characters		
?	—	1123	956
pas *aggregata* à cause des spores	—	1124	946
atrosquamosum forma?	—	1125	1182
cinerascens Quél. non Fr.	*cinerascens* Bull., poor	1126	640
humilis forma	*melaleucum* var. *polioleucum*	1127	957
truncatum	—	1128	1183
transformis Britz., si les spores sont triangulaires	—	1129	644
aggregata var.	*cinerascens*	1130	645
idem	*cinerascens*	1131	958
idem	*pergamena*	1132	643
?	*Russula*? sp.	1133	1184
cerussata forma?	*monstrosa*	1134	648
infundibuliformis forma *membranacea*	*infundibuliformis* var. membranacea	1135	646
sinopica	*sinopica*, small form	1136	647
inornata	*zygophylla*	1137	948
Tricholoma irinum?	*fodiens*	1138	949

No. of bound volume	No. printed on Plate	COOKE			QUÉLET
1139	950	*Agaricus (Collybia) prolixus*			*distorta*
1140	652	—	—	*distortus* var.	—
1141	650	—	—	*velutipes* var. *rubescens*	
1142	1168	—	—	*floccipes*	inconnu
1143	1167	—	—	*thelephorus*	*Mycena plicosa ?*
1144	651	—	—	*leucomyosotis*	*Mycena rugosa*
1145	649	—	—	*tenacellus*	
1146	1185	—	—	*eustygius*	*Clit. inornata*
1147	1198	—	—	*murinus*	*malè*
1148	951	—	*(Mycena) mirabilis*		*iris*
		—	—	*flavipes*	—
1149	952	—	—	*gypseus*	
		—	—	*codoniceps*	*trachelina* Fr.
1150	1186	—	—	*consimilis*	*leptocephala*
1151	653	—	—	*leucogalus*	*galopus*
1152	1152	—	*(Omphalia) chrysophyllus*		—
		—	—	*Postii*	—
1153	959	—	*(Mycena) olivaceo-marginata*		*aurantio-marginata*
		—	*(Omphalia) glaucophyllus*		
		—	—	*rusticus*	—
1154	654	—	*(Pleurotus) Ruthae*		*conchatus* ou *palmatus ?*
1155	954	—	—	*sapidus*	*conchatus*
1156	953	—	—	*columbinus*	*ostreatus*
1157	1169	—	*(Pluteus) salicinus*		*malè*
		—	*(Leptonia) asprellus*		*malè, il est gris bistre*
1158	1153	—	*(Entoloma) nigro-cinnamomeus*		inconnu
1159	960	—	*(Clitopilus) straminipes*		*Entoloma speculum*
1160	1170	—	*(Nolanea) nigripes*		*Naucoria cucumis*
		—	—	*subglobosus*	*icterina*
1161	1171	—	*(Pholiota) molliscorium*		*ombrophila*
1162	961	—	*(Inocybe) perlatus*		*fastigiata*, forme obèse
1163	1174	—	—	*violaceo-fuscus*	*obscura*
1164	1173	—	—	*fasciatus*	*pyriodora*
1165	962	—	*(Hebeloma) elatus*		
1166	963	—	—	*nauseosus*	*longicaudum*
1167	964	—	*(Flammula) purpuratus*		*Ph. confragosa ?* ou mieux *Tr. variegatum ?*
1168	1154	—	—	*nitens*	*Tr. phoenix* Mich. ou *pertinax* Fr. inconnu mais semble la même espèce
1169	1187	—	*(Naucoria) lugubris*		*malè*
1170	966	—	—	*festivus*	
1171	1155	—	—	*obtusus*	*Psil. sarcocephala* Fr.
1172	965	—	—	*hamadryas*	inconnu
1173	1172	—	—	*nasutus*	*myosotis*, variété
		—	*(Pholiota) blattarius*		*Lep. echinata*, décoloré ou *Heb. erebium* Fr. gracile
1174	1156	—	*(Galera) siligineus*		*apala, tenera*, etc.
1175	1175	—	*(Tubaria) pellucidus*		*aquosa ?*
		—	—	*muscorum*	*Galera* Q.
1176	967	—	*(Chitonia) rubriceps*		inconnu, espèce exotique
1177	968	—	*(Psaliota) sagatus*		*semota* Fr., variété adulte
1178	1188	—	*(Stropharia) merdarius* var. *major*		*squamosa*
1179	1189	—	—	*scobinaceus*	*Hyph. appendiculatum*

Maire	Rea	No. of bound volume	No. printed on Plate
distorta ?	—	1139	950
distorta	*distorta* var.	1140	652
velutipes forma *rubescens*	*velutipes* var. *rubescens*	1141	650
Mycena maura Maire ? trop grand	—	1142	1168
Mycena	—	1143	1167
?	*leucomyosotis* typical	1144	651
tenacella	*tenacella*	1145	649
Trich. immundum Berk. = *Ag. fumosus* Pers. non Fr.	—	1146	1185
?	—	1147	1198
Iris forma ?	*marginella*	1148	951
flavipes = *Renati*	*flavipes*		
gypsea ?	*gypsea*	1149	952
?			
?	—	1150	1186
galopoda var. *leucogala*	*galopus* var. *nigra*	1151	653
chrysophylla	—	1152	1152
Postii	—		
avenacea forme	*avenacea* var. *olivaceo-marginata*	1153	959
?	*glaucophylla*		
rustica	*rustica*		
palmatus	*palmatus*	1154	654
cornucopiae	*sapidus*	1155	954
ostreatus var. *columbinus*	*ostreatus* var. *columbinus*	1156	953
salicinus	*salicinus*	1157	1169
asprella	*asprella*		
?	—	1158	1153
?	*Lept. sericella*	1159	960
Nauc. Cucumis forme	*Nauc. Cucumis*	1160	1170
? e sporis potius *Pluteus*			
?	*molliscorium*	1161	1171
fastigiata forme	*perlata*	1162	961
obscura	*violaceofusca*	1163	1174
?	*fasciata*	1164	1173
elatum	*elatum*	1165	962
? ressemble à *H. sacchariolens* mais spore trop grande	—	1166	963
?	—	1167	964
? voir formes brunes exannulées de *Ph. cylindracea*	—	1168	1154
lugubris	*lugubris*	1169	1187
festiva	*festiva*	1170	966
?	—	1171	1155
?	—	1172	965
Psil. semi-lanceata	—	1173	1172
?	*blattaria*		
apala et *tenera* ?	*Galera campanulata*	1174	1156
?	—	1175	1175
?			
rubriceps	*rubriceps*	1176	967
rubella Gill ?	—	1177	968
stercoraria forma ? ou plutôt *Hyph. capnoides*	—	1178	1188
Hyph. lacrimabundum Fr. ? ou forme du groupe	*scobinaceum*	1179	1189

No. of bound volume	No. printed on Plate	COOKE	QUÉLET
1180	1176	*Agaricus (Hypholoma) catarius*	*Hyph. appendiculatum*
1181	1157	——— ——— *instratus*	*hydrophilum*
1182	1177	——— *(Psilocybe) areolatus*	*Stroph. Battarrae?*
1183	969	——— ——— *Clivensis*	*Heb. elatum* gracile ou *Heb. sacchariolens*
1184	970	——— *(Psathyra) gyroflexus*	———
1185	1158	——— ——— *conopileus* var. *superbus*	*Psathyra fatua*
1186	1160	——— *(Bolbitius) conocephalus*	*vitellinus*, blanchi; ou *apalus* exubérant
1187	1159	——— ——— *grandiusculus*	*vitellinus* var. *Boltonii*
1188	1190	*Cortinarius (Phlegmacium) testaceus*	*subpurpurascens* Fr.
1189	1191	——— *(Myxacium) nitidus*	*sebaceus* forma
1190	1192	——— *(Telamonia) lucorum*	non, *evernius*
1191	1193	——— ——— *croceo-fulvus*	*limonius* Fr.
1192	1178	——— *(Hydrocybe) angulosus*	*cinnamomeus* forma
1193	1162	*Paxillus Alexandri*	malè
1194	1161	*Hygrophorus (Hydrocybe) spadiceus*	
1195	1194	*Lactarius involutus*	*piperatus* ou *argematus?*
1196	1195	——— *squalidus*	inconnu; *blennius*, *vietus?*
1197	1197	*Russula virginea*	*delica*, forme ou *lactea*
1198	1196	——— *ochroleuca* var. *claroflava*	*olivascens* var. *citrina*

Maire	Rea	No. of bound volume	No. printed on Plate
Candolleanum forma	*catarium*	1180	1176
hydrophilum? spore trop grande	—	1181	1157
Hyph. melantinum	—	1182	1177
?	*clivensis*	1183	969
?	*gyroflexa*	1184	970
Psathyrella subatrata	—	1185	1158
?	—	1186	1160
vitellinus var.?	—	1187	1159
rufo-olivaceus, adulte, très probable-ment	*testaceus*	1188	1190
?	—	1189	1191
torvus Fr. non Quél.?	—	1190	1192
tophaceus Fr. Ricken!	—	1191	1193
venetus?	—	1192	1178
? ?	—	1193	1162
spadiceus	—	1194	1161
D'après les spores ce serait plutôt un *Clitocybe* du groupe *cerussata*	—	1195	1194
blennius?	—	1196	1195
? forme blanche de quelque autre espèce	—	1197	1197
flava Romell? et forme de *R. ochroleuca*	—	1198	1196

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1	1	59	76	117	5	175	147	233	176	291	283
2	2	60	80	118	45	176	149	234	207	292	184
3	3	61	81	119	119	177	155	235	223	293	293
4	4	62	96	120	126	178	275	236	231	294	294
5	36	63	103	121	137	179	277	237	232	295	295
6	6	64	106	122	138	180	281	238	235	296	296
7	7	65	110	123	160	181	97	239	252	297	297
8	8	66	113	124	174	182	145	240	256	298	298
9	10	67	114	125	175	183	178	241	262	299	299
10	13	68	120	126	177	184	191	242	287	300	300
11	15	69	11	127	180	185	221	243	289	301	301
12	16	70	12	128	183	186	225	244	291	302	303
13	17	71	53	129	192	187	233	245	49	303	305
14	24	72	59	130	196	188	236	246	130	304	306
15	35	73	62	131	218	189	240	247	215	305	309
16	58	74	63	132	47	190	241	248	247	306	331
17	46	75	66	133	115	191	246	249	248	307	335
18	39	76	67	134	132	192	249	250	259	308	342
19	43	77	100	135	151	193	251	251	266	309	314
20	48	78	111	136	157	194	254	252	267	310	316
21	19	79	128	137	161	195	279	253	270	311	317
22	20	80	129	138	165	196	280	254	272	312	319
23	21	81	139	139	179	197	71	255	273	313	320
24	23	82	141	140	181	198	73	256	274	314	321
25	25	83	154	141	185	199	79	257	276	315	324
26	26	84	159	142	186	200	136	258	284	316	332
27	28	85	42	143	189	201	182	259	288	317	333
28	22	86	52	144	197	202	190	260	290	318	334
29	31	87	65	145	199	203	201	261	92	319	337
30	41	88	72	146	202	204	206	262	104	320	340
31	50	89	74	147	209	205	198	263	122	321	341
32	56	90	86	148	224	206	226	264	131	322	343
33	51	91	88	149	193	207	244	265	133	323	344
34	14	92	93	150	194	208	245	266	200	324	349
35	18	93	94	151	203	209	258	267	205	325	310
36	33	94	98	152	204	210	264	268	208	326	325
37	27	95	101	153	210	211	285	269	213	327	326
38	29	96	102	154	211	212	292	270	214	328	327
39	30	97	117	155	212	213	40	271	260	329	339
40	32	98	118	156	216	214	75	272	261	330	352
41	34	99	121	157	219	215	78	273	263	331	353
42	37	100	125	158	220	216	89	274	265	332	354
43	38	101	134	159	222	217	99	275	278	333	355
44	44	102	135	160	237	218	109	276	286	334	356
45	54	103	140	161	238	219	124	277	9	335	357
46	55	104	142	162	242	220	167	278	87	336	359
47	57	105	148	163	243	221	187	279	108	337	361
48	77	106	150	164	250	222	227	280	146	338	365
49	82	107	152	165	84	223	228	281	153	339	322
50	83	108	156	166	90	224	229	282	188	340	367
51	85	109	158	167	95	225	234	283	195	341	329
52	91	110	162	168	107	226	269	284	217	342	338
53	60	111	163	169	112	227	271	285	230	343	370
54	61	112	164	170	116	228	282	286	239	344	371
55	64	113	166	171	123	229	105	287	253	345	372
56	68	114	170	172	127	230	168	288	255	346	373
57	69	115	171	173	143	231	169	289	257	347	374
58	70	116	172	174	144	232	173	290	268	348	375

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349	376	407	447	465	523	523	540	581	328	639	1111
350	379	408	449	466	524	524	542	582	408	640	1126
351	390	409	450	467	525	525	543	583	415	641	1118
352	394	410	451	468	530	526	544	584	541	642	1117
353	395	411	452	469	318	527	545	585	548	643	1132
354	401	412	453	470	330	528	546	586	578	644	1129
355	402	413	455	471	392	529	547	587	579	645	1130
356	404	414	457	472	411	530	549	588	593	646	1135
357	304	415	458	473	412	531	550	589	603	647	1136
358	377	416	459	474	471	532	551	590	608	648	1134
359	378	417	460	475	472	533	552	591	610	649	1145
360	381	418	461	476	474	534	557	592	612	650	1141
361	382	419	462	477	482	535	558	593	615	651	1144
362	383	420	463	478	502	536	559	594	616	652	1140
363	384	421	313	479	506	537	565	595	618	653	1151
364	385	422	315	480	513	538	566	596	622	654	1154
365	387	423	380	481	521	539	567	597	308	655	638
366	389	424	406	482	510	540	568	598	312	656	640
367	391	425	409	483	528	541	569	599	350	657	641
368	396	426	419	484	529	542	570	600	388	658	644
369	397	427	421	485	346	543	580	601	495	659	645
370	398	428	435	486	347	544	584	602	526	660	646
371	400	429	439	487	351	545	585	603	527	661	647
372	403	430	448	488	360	546	586	604	564	662	648
373	323	431	465	489	498	547	587	605	589	663	650
374	336	432	476	490	500	548	588	606	599	664	651
375	345	433	477	491	501	549	358	607	598	665	652
376	362	434	478	492	505	550	554	608	600	666	653
377	363	435	479	493	507	551	555	609	601	667	654
378	364	436	485	494	508	552	556	610	606	668	655
379	366	437	466	495	516	553	560	611	614	669	656
380	368	438	467	496	532	554	561	612	621	670	657
381	417	439	469	497	533	555	562	613	369	671	658
382	418	440	470	498	535	556	563	614	393	672	659
383	426	441	473	499	534	557	572	615	486	673	660
384	429	442	475	500	468	558	573	616	489	674	661
385	430	443	480	501	348	559	574	617	504	675	662
386	431	444	481	502	399	560	575	618	553	676	663
387	433	445	483	503	405	561	576	619	571	677	664
388	437	446	484	504	423	562	577	620	591	678	665
389	407	447	487	505	432	563	582	621	595	679	667
390	410	448	488	506	454	564	583	622	597	680	668
391	413	449	490	507	456	565	302	623	623	681	669
392	414	450	491	508	464	566	581	624	624	682	670
393	416	451	492	509	496	567	590	625	626	683	671
394	420	452	493	510	511	568	592	626	627	684	672
395	422	453	386	511	512	569	594	627	628	685	673
396	425	454	424	512	514	570	596	628	629	686	674
397	427	455	494	513	515	571	602	629	630	687	675
398	428	456	497	514	531	572	604	630	631	688	676
399	436	457	499	515	536	573	605	631	632	689	677
400	438	458	503	516	537	574	607	632	633	690	680
401	440	459	509	517	307	575	609	633	634	691	681
402	441	460	517	518	311	576	611	634	635	692	682
403	443	461	518	519	434	577	613	635	636	693	683
404	444	462	519	520	442	578	617	636	637	694	684
405	445	463	520	521	538	579	619	637	639	695	685
406	446	464	522	522	539	580	620	638	642	696	686

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697	687	755	721	813	847	871	836	929	868	987	925
698	689	756	750	814	855	872	861	930	890	988	931
699	690	757	752	815	748	873	863	931	891	989	932
700	691	758	757	816	765	874	862	932	893	990	934
701	693	759	758	817	769	875	867	933	898	991	935
702	694	760	759	818	791	876	869	934	900	992	936
703	695	761	760	819	792	877	870	935	902	993	937
704	697	762	761	820	796	878	871	936	907	994	955
705	698	763	762	821	797	879	856	937	905	995	957
706	699	764	763	822	807	880	857	938	906	996	959
707	700	765	768	823	809	881	858	939	1102	997	960
708	701	766	770	824	817	882	859	940	1104	998	961
709	702	767	739	825	820	883	860	941	1105	999	962
710	703	768	740	826	823	884	866	942	1109	1000	963
711	705	769	744	827	828	885	872	943	1108	1001	965
712	706	770	747	828	833	886	873	944	1112	1002	966
713	707	771	751	829	839	887	874	945	1120	1003	926
714	714	772	753	830	849	888	876	946	1124	1004	938
715	715	773	754	831	742	889	878	947	1119	1005	941
716	716	774	755	832	784	890	882	948	1137	1006	942
717	717	775	764	833	786	891	883	949	1138	1007	948
718	731	776	772	834	790	892	894	950	1139	1008	951
719	666	777	777	835	806	893	895	951	1148	1009	952
720	679	778	778	836	805	894	916	952	1149	1010	956
721	708	779	779	837	808	895	875	953	1156	1011	958
722	709	780	780	838	816	896	879	954	1155	1012	964
723	710	781	782	839	818	897	881	955	1113	1013	967
724	711	782	840	840	821	898	884	956	1123	1014	969
725	712	783	766	841	830	899	885	957	1127	1015	970
726	723	784	767	842	835	900	896	958	1131	1016	971
727	724	785	774	843	848	901	897	959	1153	1017	973
728	725	786	775	844	851	902	899	960	1159	1018	976
729	726	787	776	845	852	903	904	961	1162	1019	981
730	727	788	787	846	853	904	908	962	1165	1020	982
731	728	789	812	847	643	905	911	963	1166	1021	985
732	729	790	814	848	649	906	913	964	1167	1022	986
733	730	791	822	849	722	907	914	965	1172	1023	988
734	738	792	824	850	773	908	915	966	1170	1024	992
735	719	793	826	851	781	909	918	967	1176	1025	996
736	720	794	837	852	789	910	919	968	1177	1026	998
737	732	795	838	853	795	911	877	969	1183	1027	1018
738	733	796	841	854	810	912	880	970	1184	1028	1019
739	734	797	842	855	813	913	886	971	922	1029	1020
740	735	798	850	856	827	914	887	972	923	1030	1021
741	736	799	688	857	831	915	888	973	924	1031	1022
742	737	800	788	858	843	916	889	974	927	1032	1032
743	741	801	794	859	844	917	892	975	929	1033	1033
744	743	802	800	860	854	918	901	976	933	1034	1036
745	745	803	801	861	864	919	903	977	939	1035	977
746	746	804	802	862	865	920	909	978	943	1036	978
747	749	805	803	863	692	921	910	979	944	1037	984
748	771	806	804	864	756	922	912	980	945	1038	1026
749	783	807	819	865	793	923	917	981	946	1039	991
750	785	808	825	866	798	924	920	982	947	1040	993
751	696	809	829	867	799	925	921	983	949	1041	1001
752	704	810	832	868	811	926	1116	984	940	1042	1003
753	713	811	845	869	815	927	625	985	954	1043	1006
754	718	812	846	870	834	928	678	986	968	1044	1009

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1045	1010	1071	990	1097	1049	1123	1077	1149	1096	1175	1175
1046	1015	1072	994	1098	1054	1124	1078	1150	1098	1176	1180
1047	1016	1073	995	1099	950	1125	1079	1151	1122	1177	1182
1048	1030	1074	1000	1100	980	1126	1080	1152	1152	1178	1192
1049	1025	1075	1002	1101	1024	1127	1082	1153	1158	1179	1110
1050	1050	1076	1007	1102	1053	1128	1083	1154	1168	1180	1107
1051	972	1077	1008	1103	1055	1129	1084	1155	1171	1181	1115
1052	987	1078	1031	1104	1057	1130	1085	1156	1174	1182	1125
1053	999	1079	1039	1105	1059	1131	1056	1157	1181	1183	1128
1054	1004	1080	1041	1106	1058	1132	1067	1158	1185	1184	1133
1055	1012	1081	1035	1107	1060	1133	1071	1159	1187	1185	1146
1056	1013	1082	1051	1108	1061	1134	1081	1160	1186	1186	1150
1057	1014	1083	928	1109	1062	1135	1086	1161	1194	1187	1169
1058	1017	1084	930	1110	1063	1136	1087	1162	1193	1188	1178
1059	1023	1085	953	1111	1064	1137	1088	1163	1103	1189	1179
1060	1029	1086	979	1112	1066	1138	1089	1164	1106	1190	1188
1061	1040	1087	997	1113	1068	1139	1090	1165	1114	1191	1189
1062	1042	1088	1005	1114	1099	1140	1091	1166	1121	1192	1190
1063	1043	1089	1011	1115	1065	1141	1092	1167	1143	1193	1191
1064	1045	1090	1027	1116	1069	1142	1093	1168	1142	1194	1195
1065	1046	1091	1028	1117	1070	1143	1094	1169	1157	1195	1196
1066	1047	1092	1034	1118	1072	1144	1097	1170	1160	1196	1198
1067	974	1093	1037	1119	1073	1145	1100	1171	1161	1197	1197
1068	975	1094	1038	1120	1074	1146	1101	1172	1173	1198	1147
1069	983	1095	1044	1121	1075	1147	1052	1173	1164		
1070	989	1096	1048	1122	1076	1148	1095	1174	1163		

Toadstools and Mushrooms and other Larger Fungi of South Australia. By
JOHN BURTON CLELAND, M.D. Pp. 178 with 6 coloured plates and
35 text-figures. Adelaide, British Science Guild. 5*s.*

Those who study Agarics in this country doubtless appreciate the difficulties
of workers in distant lands. Many species occur all over the temperate regions of
the globe and several of them are readily recognised from illustrations. The
additional greater precision of modern descriptions enables some determinations
to be made with complete satisfaction. But there are endless difficulties. Some
of the earlier collections sent to Europe were named in what would now be
regarded as a rather casual manner. As a result many European species were
recorded which were really doubtful and on the other hand some species already
described from Europe were given new names. Thus an Australian mycologist,
for example, has not only to recognise European species but has also to determine
what the Australian forms are which appear in the old lists with European names.

Dr Cleland's handbook shows much evidence of these difficulties but he has
based his descriptions on the Australian forms and thus it will be possible with
further knowledge to determine the identity of the fungus described, no matter
what name is now given to it. A large proportion of the 279 species described have
been examined by the author and a considerable number are given with his name
as the authority—but there are no Latin diagnoses.

The book opens with a general introduction of 28 pages which deals with points
of interest—edibility, luminosity, habitats, uses and the like—which gains from
having reference to Australian fungi. This is followed by a glossary. Classification
is then outlined and a key is given to the genera. The arrangement of the body of
the work follows Rea and indeed the generic descriptions are taken verbatim
from *British Basidiomycetae* for all genera there listed: the additional genera are
based in the main on Killerman (Engler & Prantl).

The handbook will prove of considerable value to mycologists interested in
distribution because of the indication it gives of the species of Agarics found in
South Australia. It will moreover doubtless do much to stimulate the study of the
group amongst those for whom it was primarily written. It forms one of the series
of Handbooks of the Flora and Fauna of South Australia whose preparation has
been undertaken by the South Australian Branch of the British Science Guild,
and the State Government prints the work and publishes it at cost price: the
present volume costs less than four shillings in English money. It is to be hoped
that such a liberal-minded governmental attitude towards biological science will
meet with success in every way and encourage other legislators to act similarly.

J. R.

NOTES ON CERTAIN CHANGES IN NOMENCLATURE IN THE SECOND EDITION OF THE LIST OF COMMON NAMES OF BRITISH PLANT DISEASES

By E. M. WAKEFIELD and W. C. MOORE

A standardised "List of common names of British plant diseases" was published in the Society's *Transactions* in 1929 (XIV (1929), 140–77). Recently this list has been revised* and now contains the names of seven additional hosts and some fifty additional diseases.

In this second edition of the list only a few changes have been made in the common names of the diseases, but considerable revision of the scientific names of the relevant pathogens has been found necessary both to bring matters into line with more recent research and in order to ensure conformity to the International Rules of Botanical Nomenclature as revised at Cambridge in 1930. The present article provides explanations for most of the nomenclatorial changes found necessary, and the notes are arranged in groups corresponding to the main groups under which the host plants are arranged in the list. It may be mentioned here, however, that in naming species of *Fusarium* Wollenweber's [68] classification has been followed throughout. On the other hand, since the classification and nomenclature of bacteria is at present under consideration by the International Society for Microbiology, no attempt has been made to adhere strictly to any one system of bacterial nomenclature, and the names commonly used in this country have been adopted in all instances. Many of the additions denote diseases that were not known to occur in this country at the time the list was originally prepared. Certain other diseases have now been included on account of their increased prevalence during recent years or because the host involved has come more into prominence commercially.

CEREALS

The name *Ustilago Hordei* was used for Covered Smut of barley by Lagerheim [37] in 1889, and since Kellerman and Swingle [35] did not use this combination until the following year, (Pers.) Lagerh. and not (Pers.) Kellerm. & Sw. must be cited as the authority for the name.

Ustilago Tritici presents a similar but rather more difficult case. In

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* It has been published as a separate pamphlet and is obtainable from the University Press, Cambridge.

the *Second Annual Report for* 1889 *of the Kansas Experimental Station*, appearing in 1890, Kellerman and Swingle ((35), p. 261) first published the name *U. Tritici* (Pers.) Jens., on the basis of information given in a letter received from Jensen and dated January 24th, 1890. This combination has been quoted by most later authors and was adopted in the first edition of the list. As pointed out by Liro (40), however, the same combination was also made by Rostrup (58) on March 31st of the same year. The *Kansas Report* for 1889 bears only the date 1890, but in the Report of the Council given in the *Kansas Third Annual Report for* 1890 (1891), pp. vii–xii, it is stated that "the second annual report (1889) . . . was issued from the press of the Kansas Publishing House in June". Rostrup's article therefore antedates that of Kellerman and Swingle, and for this reason the name *U. Tritici* (Pers.) Rostr. is now cited.

The double citation, (Bri. & Cav.) Eid., used for *Helminthosporium Avenae* in the first edition was a mistake which appears to have originated in a paper by Ravn (56) and was not detected at the time the list was prepared. This fungus was originally named as var. *Avenae-sativae* of *Helminthosporium teres* by Briosi and Cavara (8). When Eidam (23) raised it to the rank of species he used the epithet *Avenae*, and not *Avenae-sativae*. Article 58 of the Rules states that when the rank of a group is changed the earliest legitimate name or epithet given to the group in its new rank is valid, provided it is not a later homonym. Accordingly the correct name for the fungus as a species is *Helminthosporium Avenae* Eid., and this cannot be discarded in favour of *H. Avenae-sativae* (Bri. & Cav.) as was done by Lindau (1910, in *Rab. Krypt.-Fl.* ed. 2, Bd. 1, Abt. 9, p. 35). Ravn's use of (Bri. & Cav.) in parenthesis for the epithet *Avenae* was either a *lapsus calami* or due to a misunderstanding of the significance of brackets in citations of authors' names. Both *Pyrenophora Avenae* Ito and *Pleospora Avenae* Schaffn. & Rathschl. have been described as the perfect stage of *Helminthosporium Avenae*, and the first named has recently been recorded in Britain by Dennis (18).

Diedicke (19), in 1903, merely surmised the existence of a "*Pleospora teres*" on barley; he did not see it. Hence his combination is not valid, and Drechsler's (22) *Pyrenophora teres* is the first legitimate name given to the perfect stage. The correct citation is therefore *P. teres* Drechsl. and not *P. teres* (Died.) Drechsl. as previously given.

A disease of oats occurring in Wales and previously believed to correspond to Halo Blight (*Bacterium coronafaciens* Ch. Elliott) has now been shown by Davies and Jones (16) to be identical with the non-parasitic Grey-Leaf. There is no evidence that true Halo Blight occurs in Britain, and the entry has therefore been deleted.

PULSE

Further studies of Chocolate Spot of broad beans have made it doubtful whether this disease is caused by *Bacillus Lathyri* Manns & Taubenh. Riker and Riker(57) suggest that a bacterium closely resembling *Pseudomonas seminum* Cayley might be involved, whilst unpublished work carried out at Cambridge appears to show that the disease may be due to a fungus. Hence the insertion of a (?) before the name *Bacillus Lathyri* under broad beans and also under sainfoin, vetches and sweet pea. On the other hand, the evidence that Marsh Spot of peas is not a parasitic disease is now very strong (9, 36, 52): it is therefore classed as non-parasitic.

Until recently all the damage to pea plants associated with *Ascochyta* in this country has been attributed to *A. Pisi*. It is now known that the three diseases, caused by three distinct species of *Ascochyta*, and first differentiated in America independently by Linford and Sprague(39) and by L. K. Jones(33), all exist in Britain, although their relative importance has not yet been determined. The true *A. Pisi* Lib. produces leaf, stem and pod spotting only, and the name suggested for the disease it causes is Leaf and Pod Spot. The other two species (*Mycosphaerella pinodes* (Berk. & Blox.) Stone* and *Ascochyta pinodella* L. K. Jones) affect the plant in much the same way, but, in addition, they may attack the base of the stem, inducing a Foot Rot. These two species, together with species of *Fusarium* frequently associated with a stem rot of pea occurring in the west of England(48), are grouped together as the pathogens of a disease to which the name Foot Rot has been applied.

In the first edition Root Rot of peas was ascribed to *Aphanomyces euteiches* Drechsl. and to *Thielavia basicola* Zopf. In 1912 Ferraris(24) applied the name *Thielaviopsis basicola* to what was considered to be the imperfect stage of the last-named fungus, in order to distinguish it from the ascospore stage. He did not, however, imply the existence of two distinct fungi. In 1925 McCormick(43) brought forward evidence, based on cultural work, which strongly suggested that *Thielavia basicola* and *Thielaviopsis basicola* are not genetically connected, although often associated with one another. Since it is the conidial stage that is commonly found associated with rotting of pea roots in Britain the name *Thielaviopsis basicola* (Berk. & Br.) Ferraris has been selected in preference to *Thielavia basicola* Zopf, and the opportunity has been taken to distinguish Black Root Rot due to this fungus from Root Rot due to *Aphanomyces*.

* The name Niessl was left in the list by an oversight. Niessl called the fungus *Sphaerella*. The change to *Mycosphaerella* was made by Stone (*Ann. mycol.* x (1912), 581).

POTATO

The only significant emendation made in the section dealing with potato diseases is that relating to Spraing. Brown spotting or streaking of the flesh of potato tubers, quite distinct from the brown decay due to blight, has been known in Britain for over half a century, but its true nature and origin have always been, and still are, a matter of considerable uncertainty. In England the malady was at first called Canker or Internal Disease, but later the Scottish term Sprain or Spraing came into more general use, both in this country and in Ireland. Horne (31) clearly distinguished two diseases in this category and called them Blotch or Internal Disease, and Sprain or Streak Disease. In Blotch, larger or smaller, brown or chocolate specks, spots or blotches were distributed throughout the flesh of the tubers, whilst in Sprain the markings were usually arc-like or curved in section and often arranged concentrically. Later, Paine (49) introduced the name Internal Rust Spot to include both these sets of symptoms; and they remained grouped together until quite recently, when Grieve (26) segregated them again. In the present list the name Spraing is retained for the disease exhibiting arc-like lesions and the term Internal Rust Spot is applied to the blotch type of lesion. It should be noted, however, that these two types of lesion occasionally occur together in the same tuber. There is at present no evidence that the allied diseases Pseudonetnecrosis and Net Necrosis occur in this country. Spraing has been attributed by different workers to non-parasitic causes (25), to bacteria (10) and to virus agency (26, 55), and the last-mentioned is adopted provisionally in the list. There is some evidence that Internal Rust Spot may be bacterial in nature (10, 26, 49), but the matter has not yet been satisfactorily elucidated.

ROOT CROPS

Opinions differ as to the appropriateness of the names Finger-and-Toe and Club Root for the disease of Crucifers caused by *Plasmodiophora Brassicae*. In this country usage is about equally divided between them, but in parts of the Empire (15) Club Root appears to be preferred, and largely on account of this the name Finger-and-Toe has now been replaced by Club Root as a common name under turnip, cabbage, radish, seakale and wallflower.

In the first edition Soft Rot of turnip and swede was ascribed to two distinct organisms, *Bacillus carotovorus* L. R. Jones and *Pseudomonas destructans* Potter. The original cultures from which Potter (53) described his organism as a uniflagellate rod were lost, but two later isolations by Potter, which he believed to be identical with his original isolation, were found by Harding and Morse (28) to consist of an organism with peritrichiate flagella which they regarded as

specifically identical with *Bacillus carotovorus*. Since Potter (54) himself appears to have accepted this interpretation the disease is now attributed to *B. carotovorus* only.

White Spot of turnip, previously ascribed to *Cercospora Bloxami* Berk. & Br., is now attributed to *Cercosporella Brassicae* (Fautr. & Roum.) v. Hoehn.*

VEGETABLES

For many years the Downy Mildew of onions and of shallots has been known as *Peronospora Schleideni* Unger, and this was the name included in the first edition of the list. In 1932, however, Cook (13) endeavoured to prove that it should be called *P. destructor* (Berk.) Caspary. Unfortunately Article 57 of the International Rules, concerning the names of fungi having a pleomorphic life cycle, does not mention the Phycomycetes. Mycologists, however, appear to be agreed that the rule should apply to this group also, and it is therefore necessary to discover the name first given to the "perfect" or oospore stage.

The conidial stage of the onion Downy Mildew was first described by Berkeley (6), in 1841, as *Botrytis destructor* Berk., but later, in 1860 (7), he listed it as *Peronospora destructor* Casp. Unger's name *P. Schleideni* dates from 1847 (66), and similarly applies only to the conidial stage. In 1855 Caspary (11) described oospores of various species of *Peronospora*, but there seems to be no evidence that he ever saw those of the onion fungus, and he himself does not appear to have published the combination *P. destructor*. Cook (13) maintained that because Berkeley used this name for his fungus, and mentioned in the generic description of *Peronospora* that the genus produces oospores, therefore the name *P. destructor* was applied to the perfect stage. The argument is false, however, and it cannot be assumed that Berkeley received a private communication from Caspary stating that he had seen oospores. It seems much more probable that Berkeley merely followed Caspary in including this species in the genus *Peronospora* on general grounds. In point of fact, three years after publication of the name *P. destructor* by Berkeley, de Bary (17) wrote of the onion fungus "oosporis ignotis".

As far as can be ascertained the oospores of onion Downy Mildew were first mentioned by W. G. Smith (62) in 1884. He gave an illustration of them and stated that they had been found by Vize in decaying patches on onions that had previously borne the conidial stage. Shipley (61) fully described the oospores, and his illustrations of them were drawn by W. G. Smith. In both instances the name used was *P. Schleideniana*, a combination made by de Bary (17) in 1863. De Bary's name was nevertheless invalid, for he merely applied it instead

* See p. 110.

of *P. Schleideni* to the conidial stage, and names cannot be changed arbitrarily. Since W. G. Smith used this combination for the oospore stage, however, it is correct to call the fungus *P. Schleideniana*, but the name must be attributed to W. G. Smith and not to de Bary.

The laws of priority necessitated the change from *Colletotrichum oligochaetum* Cav. to *C. lagenarium* (Passer.) Ell. & Hals. for the fungus causing Anthracnose of cucumber. This organism was first described in 1867 by Passerini (50) as *Fusarium lagenarium*, and it was transferred, first to *Gloeosporium* and later, in 1893, by Halsted (27) to *Colletotrichum* as *C. lagenarium* Ell. & Hals. Meanwhile, in 1889, Cavara (12) had described what is now regarded as the same species, as *C. oligochaetum* and his name is commonly but incorrectly given to the fungus.

The organism causing Bacterial Spot of lettuce is *Bacterium marginale* N. A. Brown and, adopting a suggestion by Prof. S. G. Paine, this name is no longer given as a synonym of *B. pyocyaneum* (Gessard) Lehm. & Neum. (45). Paine has pointed out (*in litt.*) that when first isolated from affected lettuce *B. marginale* does not exhibit the deep green colour of *B. pyocyaneum*; moreover, the last-named is regarded by medical workers as a human pathogen and, until further information is forthcoming, it is desirable to avoid possible exaggeration of the importance of this organism in comparative animal and plant pathology.

The authority for the name *Marssonina panattoniana* Berl. is now correctly given as (Berl.) Magn. In 1906 Magnus (42) showed that the name *Marssonia* (often wrongly spelt *Marsonia*) was given by Karsten to a Phanerogamic genus in 1861, thirteen years before Fischer chanced upon the same name to designate a fungus. Fischer's name was therefore an invalid one and Magnus replaced it by *Marssonina*, to which he transferred various species, including *M. panattoniana* Berl. The use of brackets for Berl., the first author of the epithet *panattoniana*, is, of course, in accordance with Article 49 of the International Rules, which lays down that when a species is either transferred to another genus, or altered in rank, but *without changing its specific epithet*, the name of the original author must be cited in parenthesis.

Recent investigations (3) have permitted more precise definition to be made of the virus diseases of tomato, and Spotted Wilt, Mosaic, Yellow Mosaic and Streak are now differentiated. In the past the last-named has often been called Stripe, but it is considered desirable to reserve the name Stripe for the disease ascribed to *Bacillus Lathyri* Manns & Taubenh. The term Streak as now applied embraces four distinct Streak diseases caused by different viruses but indistinguishable by their symptoms alone. Only two of these, viz. Single-virus Streak and Mixed-virus Streak, are known to occur in this country.

The common name for the disease of cabbage due to *Phoma*

Lingam (Tode) Desm. has been changed from Stem Rot to Canker to meet a criticism made by Cunningham(15).

FRUIT

Changes have been made in the name and authorities of the two Brown Rot fungi *Sclerotinia fructigena* Schroet. and *S. cinerea* Schroet. wherever they occur in the list. In 1893, Schröter(59), who contributed the section on fungi to Cohn's *Kryptogamen-Flora*, discussed the two species *Monilia fructigena* and *M. cinerea* and named them *Sclerotinia fructigena* and *S. cinerea* respectively. Reference to his descriptions, however, shows clearly that he did so only by analogy, for he stated that the perfect stages of these fungi had not been found. His combinations are therefore invalid.

As pointed out by Harrison(29), the first description of the perfect stage of *Monilia fructigena* appears to be one by Aderhold and Ruhland(2) in 1905, and the correct citation for the common fruit-rotting fungus of Europe having buff-coloured fructifications is therefore *Sclerotinia fructigena* Aderh. & Ruhl.

In the same article Aderhold and Ruhland described two other fungi in their perfect stages, viz. *Sclerotinia laxa* and *S. cinerea*. The account of *S. laxa* was based upon European material, and this would appear to be the first description of the perfect stage of what has long been known in Europe as *Monilia cinerea* Bon. The strains of this fungus that cause Brown Rot, Blossom Wilt and allied diseases of pear, plum, cherry, apricot and peach all appear to be identical, and they should all be included under the name *Sclerotinia laxa* Aderh. & Ruhl. The strain that causes Brown Rot and Blossom Wilt of apple is apparently a distinct biologic form, known hitherto as *S. cinerea* f. *Mali*, but now correctly named *S. laxa* Aderh. & Ruhl. f. *Mali* (Worm.) Harrison(29).

Aderhold and Ruhland's description of *S. cinerea*, on the other hand, was based on material received from America, and these authors were mistaken in assuming that they were dealing with the perfect stage of the European *Monilia cinerea* Bon. In point of fact they had before them a specimen of the common American Brown Rot fungus, now generally called *Sclerotinia fructicola* (Wint.) Rehm, which is unknown in this country. Indeed, it is very doubtful whether it occurs normally in Europe, although it was isolated once some years ago in Holland from an apple fruit.

Cooke(14), in 1866, first described the ascigerous stage of the Apple Scab fungus as *Sphaerella inaequalis*. The combination *Venturia inaequalis*, usually attributed to Aderhold(1), was actually made by Winter much earlier and was used in Thuemen's *Mycotheca Universalis*, Nos. 261, 650 and 1544, issued 1875, 1877 and 1880 respectively. The name was used by Winter in a rather wider sense than it is now,

but that does not affect its validity, and the correct citation is *V. inaequalis* (Cooke) Wint. For precision "emend. Aderh." may be added, since the type of Cooke's *Sphaerella inaequalis* was a form on *Pyrus Aria* and not on apple.

With regard to the species of *Myxosporium* causing Surface Canker of apple, since the mistake is so often made it seems desirable to point out that the specific epithet should be *corticola* and not "*corticolum*", as was wrongly used by Edgerton. Latin words ending in -*cola*, as *incola, agricola, terricola*, are not adjectives, but nouns of common gender, formed from the stem *col*. There is no corresponding adjectival form. The specific epithet *corticola* is thus a noun in apposition, meaning an inhabitant of the bark; it cannot be declined like an adjective. The perfect stage of this fungus has not yet been found in this country, but it is known on the Continent under three different names. Madame Arnaud (4) first described it in France in 1923 as *Dermatea corticola* Arn. In 1930 Jørgensen (34) encountered what is clearly the same organism in Denmark, but he was apparently unaware of Arnaud's work and regarded his fungus as new to science, naming it *Neofabraea corticola*. More recently Nannfeldt (47) has considered the genus *Neofabraea* to be synonymous with *Pezicula*, and has called the apple fungus *Pezicula corticola* (Jørgens.) Nannf. The correct double citation under *Pezicula*, if the synonymy is correct, should be *P. corticola* (Arn.) Nannf.

Physalospora obtusa (Schw.) Cooke has been substituted for *P. Cydoniae* Arn. as one of the causal agents of Leaf Spot of apple, in accordance with recent investigations by Stevens (63), and similarly *Plectodiscella veneta* Burkh. has been replaced by *Elsinoe veneta* (Burkh.) Jenk. for Anthracnose of raspberry (32), while *Gloeosporium ampelophagum* (Pass.) Sacc. has been listed as a synonym of *Elsinoe ampelina* Shear for Anthracnose of grape vine (60). As regards Rust of black currants, *Cronartium ribicola*, Sydow (64) has submitted legitimate reasons for citing J. C. Fischer instead of Diet. as the authority for the name.

Loganberry Rust and Branch Die Back of plums have been deleted from the list on account of their apparent rarity in this country. Rough Scab of apples has also been omitted, since in view of recent research by Moore (46) it is very doubtful whether this name can be applied to any specific disease, or whether the fungus to which it was attributed (*Coniothecium chomatosporum* Corda) can be regarded as actively parasitic. On the other hand, there are now more cogent reasons for regarding the Sooty Blotch fungus on apples in this country as identical with *Gloeodes pomigena* (Schw.) Colby, and a correction to this effect has been made.

Recent investigations have helped considerably to elucidate the obscurity regarding Die Back in plum trees. Bacteria were pre-

viously thought to be implicated, and Wormald's work (69) has now revealed the existence of a specific disease caused by *Pseudomonas mors-prunorum* Worm. This disease has therefore been removed from the congeries of undetermined diseases included under the term Die-Back and has been named Bacterial Canker.

ORNAMENTALS

The only change made in the common names under this section is the replacement of the name Stalk Break by the more appropriate term Loose Bud for a non-parasitic condition not infrequently exhibited by hyacinths (51).

The discovery and naming of the perfect stage of the gladiolus Dry Rot organism, *Sclerotium Gladioli* Massey, enables attention to be drawn to a further point in nomenclature often unappreciated by plant pathologists. In fungi with a pleomorphic life cycle, the name to be used is the earliest given to the state which it has been agreed to call the perfect form, provided that this name is otherwise in accordance with the International Rules (Art. 57). It frequently, indeed usually, happens that the author describing the perfect stage uses the same specific epithet as that of the conidial or sterile form previously known. Many writers cite the name of the author of the conidial stage in parenthesis. For instance, when Drayton (21) found that *Sclerotium Gladioli* Massey produces a *Sclerotinia* as the perfect state he wrote its name *Sclerotinia Gladioli* (Massey) Drayton. Since the *Sclerotinia* was a fungus described *de novo*, however, and it was not merely a question of changing an existing name which already had a full description, the case is not quite the same as that provided for in Art. 49. If the ascigerous stage had previously been described as *Peziza* by Massey, the double citation (Massey) Drayt. would have been correct. The two cases are not parallel, and for this reason the brackets have been omitted here and in all instances where it is known that the first author described only the conidial or imperfect stage.

Phytophthora Richardiae Buism., the causal agent of Root Rot of arum (*Richardia*), is considered by Ashby (5) to be merely a variety of *P. cryptogea* and it is now listed as *P. cryptogea* Pethybr. & Laff. var. *Richardiae* (Buism.) Ashby.

As shown by Wollenweber ((68), p. 499) the carnation Leaf Rot fungus described by Höstermann and Laubert in 1921 as *Pseudodiscosia Dianthi* is identical with *Excipulina valtellinensis* Trav. (1903). This fungus is, however, a *Heteropatella* and its correct name is *H. valtellinensis* (Trav.) Wr.

A description of the species of *Penicillium* that causes Storage Rot of gladiolus was published from two sources early in 1928, and in both instances the name *P. Gladioli* was used. A preliminary account

of it was published by McCulloch and Thom(44) in No. 1730 of *Science*, issued on February 24th, 1928, and these authors were cited as the authorities for the name in the first edition. Machacek(41), however, described the same fungus under the same name in the *19th Ann. Rep. Quebec Soc. Prot. Plants for* 1926–7, Quebec, 1927, p. 77, and, in 1930, Thom(65) ascribed priority of publication to Machacek. This view was adopted in the second edition, but subsequently it was discovered that according to Drayton(20) the publication containing Machacek's description was not distributed until February 28th, 1928. The correct authority for the name is therefore McCull. & Thom, as given in the first edition.

Although no change has been made in the name *Botrytis Tulipae* for Fire of tulips, enquiries have been received from time to time as to the reason for citing (Lib.) Lind as the authority instead of (Lib.) Hopk. It may be pointed out, therefore, that when Hopkins(30) made the combination in 1921 he overlooked the fact that Lind(38) had already used the same combination eight years previously.

Under iris Soft Rot *Bacillus omnivorus* van Hall has been listed as a synonym of *B. carotovorus* L. R. Jones in accordance with modern opinion, and delphinium Mildew, previously listed in error as *Erysiphe Cichoracearum* DC., has been correctly named *E. Polygoni* DC.

Recent unpublished work* in this country has demonstrated that Wilt of carnations, as previously understood, is not a single specific disease due to certain species of *Fusarium* but is a mixture of two or three distinct diseases. One of these—and perhaps the least important economically—has been differentiated as Die-Back (*Fusarium culmorum* (W. G. Sm.) Sacc.). The others are grouped together for the time being under the common name Wilt and Stem Rot, attributed to species of *Verticillium* and *Fusarium*.

In view of Waterman's(67) conclusions that *Coniothyrium Fuckelii* Sacc. and *C. Rosarum* Cooke & Harkn. are identical it was decided to omit Graft Disease as a rose disease distinct from Stem Canker. Since the perfect stage of the fungus has been found in this country Stem Canker is now attributed to *Leptosphaeria Coniothyrium* (Fuck.) Sacc. The so-called Brand Canker, due to *Coniothyrium Wernsdorffiae* Laub., has not yet been found in England.

In the first edition Leaf Spot of viola and violet was attributed in part to *Ascochyta Violae* Sacc. & Speg. From examination of typical specimens during the past few years, however, it would appear that the fungus commonly causing Leaf Spot of violets in this country does not correspond to the original description of *A. Violae* Sacc. & Speg. It not infrequently produces two-celled spores and is therefore perhaps correctly to be regarded as a species of *Ascochyta*, but

* For a brief reference to the results of this research see *The Fruit Grower*, LXXVII (1934), 179.

in general it seems to agree closely with the description of *Phyllosticta Violae* Desm., and it is provisionally referred to that species. As a cause of Leaf Spot in violas and pansies *P. Violae* appears to be uncommon in England, and this entry has accordingly been deleted.

MISCELLANEOUS

Thielavia basicola Zopf is renamed *Thielaviopsis basicola* (Berk.) Ferraris (see p. 99) under Root Rot of tobacco, and a short list of fungi known to attack lawn grasses in this country has been added. Little attention has hitherto been paid to turf diseases, and for the present no useful purpose would be served by attempting to apply common names to them.

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ON *CERCOSPORA BLOXAMI* BERK. & BR.

By E. W. MASON

Two fungi are passing in current literature as "*Cercospora Bloxami* Berk. & Br." The first is especially associated with white spot of turnip leaves in this country, but, beyond this fact, has no apparent connection with Berkeley or Broome or Bloxam. It is represented in the Kew Herbarium by the following specimens: G. H. Pethybridge, Devon, 30. x. 24; N. C. Preston, Newport, Salop, x. 24; W. Buddin, Dorset, 12. iii. 26; E. M. Wakefield, Kingthorpe nr. Pickering, Yorks, 18. ix. 30. This is clearly the fungus that was officially recognised by the Plant Pathology Sub-Committee of this Society in 1929 as *Cercospora Bloxami* Berk. & Br. Consideration of Roumeguère's Fungi sel. exsic. 5679, preserved in the same herbarium, shows that it is also *Cylindrosporium Brassicae* Fautr. & Roum., which was described in 1891 on "*Brassica Napo-brassica* Vilm." and which von Hoehnel in 1924 referred to the genus *Cercosporella* as *Cercosporella Brassicae* (Fautr. & Roum.) von Hoehn.

The second is especially associated with cabbage leaves (*Brassica oleracea* and *B. sinensis*) in the tropics,[*] and, if I am correctly informed, has not been collected in this country. It is represented in the Kew Herbarium by C. G. Hansford, No. 1296, on cauliflower, Kampala, Uganda, June, 1930, and in the herbarium of the Imperial Mycological Institute by W. F. Steven, San Juan, Trinidad, 11. iv. 34. This is *Cercospora brassicicola* P. Henn., as represented at Kew by Baker's *Fungi Malayana*, No. 17 (det. Sydow.).

There is not the slightest difficulty in distinguishing these two fungi: *Cercosporella Brassicae* is white to the naked eye, and, under the microscope, the conidia are typically cylindrical and rounded at both ends. *Cercospora brassicicola* appears to the eye as little blackish tufts; and each conidium, which typically tapers from the base to the apex, has a broad scar right across its base; associated with this, and quite as characteristic, is the presence of brown conidiophores with corresponding broad scars. The only point at issue is to which of these two fungi the name *Cercospora Bloxami* should be applied.

The species was described in *Ann. Mag. nat. Hist.* Ser. 5, IX (1882), 183, as follows:

"1979. *Cercospora Bloxami*, B. & Br. Maculis orbicularibus pallidis; sporis elongato-fusiformibus utrinque acuminatis multiseptatis.—On decaying leaves of turnips, Twycross, Rev. A. Bloxam. Formerly distributed as *Septoria Bloxami*."

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[*] It is also well known in the United States.

There is a specimen at Kew from Berkeley's herbarium, labelled by Berkeley "*Septoria Bloxami* B. & Br." On the envelope is written "on decaying leaves of turnips, Twycross. Unknown to me, A.B." [A. Bloxam]. Three spores have also been figured by the same hand at a low magnification; they appear elongate fusiform, multiseptate (up to 14 cross-septa) and acuminate at the ends. Examination of the specimen shows that the spores figured (and to which the diagnosis undoubtedly refers) are those of the fungus *Alternaria Brassicae* (Berk.) Bolle*; these are there in abundance, but nothing else is to be found.

This then is clearly the type specimen of "*Cercospora Bloxami*", which was overlooked for so long because Berkeley had not relabelled his "*Septoria Bloxami*"; and this specific epithet is accordingly not available for either of the two fungi to which it is being currently applied.

The correct name for the first appears to be *Cercosporella Brassicae* (Fautr. & Roum.) v. Hoehn. in *Ann. mycol.* xx (1924), 193, synon. *Cylindrosporium Brassicae* Fautr. & Roum. in *Rev. mycol.* xxii (1891), 81. From a consideration of their diagnoses, Hoehnel also suggested that *Cercospora* (*Cercosporella*) *albomaculans* Ell. & Ev. (1894) and *Ramularia Rapae* Pim (1897) were synonyms, and (quite rightly) that *Cercospora Bloxami* Berk. & Br. had multiseptate spores, and was therefore distinct. Authentic material of neither *Cercosporella albomaculans* nor of *Ramularia Rapae* is preserved at Kew, but von Hoehnel's surmise is very probably correct.

The correct name for the second species appears to be *Cercospora brassicicola* P. Henn., although in this case it does not seem certain that authentic material has been examined in recent times. The type collection is not preserved in Berlin, but, Prof. Dr E. Ulbrich thinks, may possibly exist in Tokyo, Japan.

* As cited in "The List of Common Names".

THE SPORULATION OF *HELMINTHOSPORIUM AVENAE* AND *ALTERNARIA SOLANI* IN ARTIFICIAL CULTURE

By W. A. R. DILLON WESTON, M.A., Ph.D.

(School of Agriculture, Cambridge)

SOMETIMES there exists a diversity of opinion as to the ease with which a fungus produces spores in artificial culture. Such is the case with the various species of *Helminthosporium*. In view of conflicting statements, Turner and Millard[1] made a detailed study of a culture of *H. Avenae*. A wide range of media was used to embrace varying carbohydrate and nutrient contents, hydrogen-ion concentration and sterilisation methods. No sporulation occurred on any of the cultures excepting on sterilised oat leaves, and then only sparsely. Shortly after this work was published, Dillon Weston[2] stated that abundant sporulation could be promoted by the irradiation of artificial cultures with a Hanovia quartz mercury-vapour home-model alpine sun-lamp, alternating current equipment 200 volts.

It is the purpose of this note to indicate the salient points of this work, and to show how sporulation of the fungus causing Early Blight, *Alternaria Solani*, may be induced by similar methods.

HELMINTHOSPORIUM AVENAE

After it had been found that this fungus would sporulate when irradiated with an artificial source of light such as a quartz mercury-vapour lamp, it was necessary to determine the time of irradiation that was necessary at a given distance from the source of light and whether this phenomenon depended upon invisible ultra-violet light or visible white light.

Non-sporing cultures were made in Petri dishes and also in watch-glasses, with watch-glass tops as covers, and were irradiated for ten minutes at a distance of one foot from the source of light. Some cultures were irradiated through the normal Petri plate covers and others through substituted covers made of a proprietary glass named Sanulux that gave a very considerable transmission at 300 $\mu\mu$. Sporulation was abundant in these cultures, while non-irradiated cultures made at the same time and under the same conditions failed to spore. This was confirmed by Mr C. C. Brett, of the Official Seed Testing Station, Huntingdon Road, Cambridge. He irradiated non-sporing cultures for five minutes through Sanulux glass with the result that abundant spore formation took place.

The time period was then reduced and cultures were irradiated for periods between one minute and ten, through the ordinary glass cover and through Sanulux glass. At all periods within this range and under both types of glass, sporulation took place. It was noted that the longer periods of irradiation produced an increase of pigment.

Cultures were also exposed for varying periods to natural irradiation out-of-doors. Some cultures were covered by Sanulux discs, others by the ordinary glass. In all the experiments sporulation took place, but control cultures with blackened surfaces did not sporulate. No attempt was made to determine the time period necessary out-of-doors, since the natural light conditions are variable. On a day during the first week in March, 1933, cultures were exposed for 2 hours 35 min., from 1.55 to 4.30 p.m. Sporulation resulted.

These experiments show that sporulation can be induced by irradiation with natural or artificial light-sources. They suggest, however, that irradiation between 320 and 295 $\mu\mu$ is not the dominant factor in causing spore formation, since it takes place through ordinary glass.

Experiments were then made to see if spore formation could be brought about if the visible light and the shorter ultra-violet rays were screened off. The lamp was screened with a Hanovia diagnosis filter. This cuts out the visible light and transmits ultra-violet between 400 and 300 $\mu\mu$, the main portion of the ultra-violet being furnished by the line 366 $\mu\mu$. Cultures were irradiated for varying periods up to twenty minutes, but no spore formation took place.

As it seemed that sporulation was brought about by visible light and not ultra-violet light, cultures were irradiated to determine the shortest period that would be necessary for exposure.

Cultures made in watch-glasses were exposed for varying periods of from one to sixty seconds. In one series they were irradiated through watch-glass covers and in another series with these covers removed. When exposed directly to the artificial light source sporulation was noted at the exposure made for two seconds and at the periods above this. When irradiated through glass covers, spore formation was delayed and was not noted until the exposure had been made for twenty seconds. Cultures were also made in watch-glasses and placed inside a photographic camera, the lens of which had been removed. This was then placed one foot below the artificial light source. Exposures were made by operating the automatic shutter. Different cultures were exposed for 1/25th, 1/50th and 1/100th of a second and also for periods of from one to thirty seconds. No sporulation resulted. As irradiation through a glass cover had increased the time period necessary, and since spores did not develop after cultures were irradiated for thirty seconds through the diaphragm of a camera,

it was inferred that sporulation depended upon the intensity of the light.

Eight Petri plate cultures were then exposed for fifteen minutes at varying distances from the source of light, the beam being parallel to the cultures. Spore formation took place when the plates were at distances of two, three and four feet—but not further than this. At two feet more spores were formed than at three, and at four feet only a few spores were noted. Controls not irradiated did not spore.

During the course of the experiments the following facts were observed. Spore formation took place about eighteen hours after irradiation. The longer the period that cultures were exposed to light the greater was the degree of pigmentation. If the cultures were not over-exposed the spores germinated normally. If irradiated for long periods the germination was injured.

ALTERNARIA SOLANI

Potato haulm was received from Dr R. Salaman of the Potato Virus Station, Cambridge, in the summer of 1933. This showed the typical "target-like" lesions of the Early Blight fungus, *Alternaria Solani*. It was, however, difficult at that date to determine the causal organism because spore formation on the material was sparse. After the material had been kept in a moist chamber for ten days spores were noted, and of these some were seen to belong to species of *Alternaria*. Cultures were made but few spores developed. Stevens(3) says: "The mycelium grows luxuriantly within the leaf but spores do not usually form until after the death of the supporting tissues when the conidiophores emerge through the stomata or by rupturing the epidermis. Often no spores are formed and rarely are many present."

As it was thought that light might be a factor influencing spore formation, cultures were irradiated. In order to cut out injurious ultra-violet rays a piece of plate glass $\frac{1}{4}$ in. thick was placed between the source of light to which the cultures were exposed for ten minutes. Eighteen hours later there was profuse sporulation. Cultures exposed out-of-doors also sporulated.

DISCUSSION OF RESULTS

It appears that visible white light of a high intensity acts as a stimulus for the formation of spores in *Helminthosporium Avenae* and *Alternaria Solani*. If this is so there is some call for the use of an incubator under thermostatic and light control. In the laboratory there must be diminished light intensity, and it may be that this intensity is often not sufficient for the production of spores. An incubator of such a type if built for indoor laboratory use would, of course, require artificial illumination. Alternatively an apparatus could be designed for use out-of-doors in natural light.

SUMMARY

1. *Helminthosporium Avenae* and *Alternaria Solani* sporulate abundantly when exposed to a high light intensity.

2. Sporulation is induced by high intensity of visible white light.

3. Continued high light intensities increase the pigmentation.

4. It is suggested that there may be a need for an incubator under thermostatic and light control.

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THE GENUS *MILESIA* IN GREAT BRITAIN AND IRELAND

By LILLIAN M. HUNTER

ALTHOUGH the type of the genus *Milesia* was described from Scotland, yet up to the present there are very few records of the species of *Milesia* for Great Britain and Ireland (Grove, W. B., *The British Rust Fungi* (1913), Cambridge; Grove, W. B., "The British species of *Milesina*", *J. Bot.* LIX (1921), 109–10; Grove, W. B., "Mycological notes. VI", *J. Bot.* LIX (1921), 311–15; Wakefield, E. M., "The Belfast Foray", *Trans. Brit. mycol. Soc.* XVII (1932), 5–15; Faull, J. H., "Taxonomy and geographical distribution of the genus *Milesia*", *Contr. Arnold Arb.* II (1932), 1–138). Likewise the only published accounts of life histories of species of *Milesia* from Europe are those of Klebahn (Klebahn, H., "Kulturversuche mit Rostpilzen", *Z. PflKrankh.* XXVI (1916), 257–77) for *M. Blechni* (Syd.) Arth. and Mayor (Mayor, "Eug. Notes Mycologiques VIII", *Bull. Soc. neuchatel. Sci. nat.* LVIII (1933), 23–26) for *M. Kriegeriana* (Magnus) Arth. from *Dryopteris Filix-mas* (L.) Schott. It was my privilege during 1933–4 to make certain studies on rusts in England, and one important part of this work was to investigate the life histories of various species of *Milesia*. A preliminary statement of the results of these investigations on *Milesia* is included here. Accessory to this work much material was assembled both by personal collecting and through the help of others. These collections add to the species already reported for Great Britain and Ireland and to the stages known there for some of the others.

I

Inoculation experiments with basidiospores from the teleutospores of *Milesia* species on their fern hosts were made on various *Abies* species (Hunter, L. M., "Preliminary note on Life History Studies of European species of *Milesia*", *J. Arnold Arb.* XVI (1935)) and spermogonia and aecidia of the following rusts were obtained for the first time:

(1) *Milesia Scolopendrii* (Fuckel) Arth. (from *Scolopendrium vulgare* Smith) on *Abies alba* Mill., and *A. concolor* Lindl. & Gord.

(2) *Milesia Polypodii* B. White (from *Polypodium vulgare* L.) on *Abies alba* and *A. concolor*.

(3) *Milesia vogesiaca* (Syd.) Faull (from *Polystichum angulare* Presl.) on *Abies alba*.

(4) *Milesia Kriegeriana* (Magn.) Arth. [from *Dryopteris spinulosa* (O. F. Müller) Kuntze] on *Abies alba*, *A. concolor* and *A. grandis* Lindl.

Spermogonia and aecidia were also obtained for *Milesia Kriegeriana* (from *Dryopteris Filix-mas*) on *Abies alba*, and on two new hosts, *A. concolor* and *A. grandis*.

In all of the above-named *Milesia* spp. spermogonia appear from twenty-one to thirty days from the time of inoculation, with an average of twenty-three days. The time from inoculation until the appearance of the aecidia varies considerably for the different species as indicated below:

(1) For *M. Scolopendrii*: 67–89 days, with an average of 77 days.
(2) For *M. Polypodii*: 82–89 days, with an average of 86 days.
(3) For *M. vogesiaca*: 99 days.
(4*a*) For *M. Kriegeriana* (from *Dryopteris spinulosa*): 46–59 days, with an average of 53 days.
(4*b*) For *M. Kriegeriana* (from *Dryopteris Filix-mas*): 60–72 days, with an average of 64 days.

Aecidiospores obtained from culture experiments were used in inoculating various ferns with the result that uredospores were obtained for the following species:

(1) *Milesia Scolopendrii* on *Scolopendrium vulgare*.
(2) *Milesia Polypodii* on *Polypodium vulgare*.
(3*a*) *Milesia Kriegeriana* (from *Dryopteris spinulosa*) on *Dryopteris Filix-mas*, *D. spinulosa* and *D. spinulosa* var. *intermedia* (Muhl.) Underw.
(3*b*) *Milesia Kriegeriana* (from *Dryopteris Filix-mas*) on *Dryopteris Filix-mas* and *D. spinulosa* var. *dilatata* (Hoffm.) Underw.

II

Hitherto unreported collections of *Milesia* spp. found in Great Britain and Ireland are listed below:

Milesia Blechni (Syd.) Arth. on *Blechnum Spicant* (L.) With.: Kilmun, Argyllshire, Sept. 26, 1932; Benmore Estate, Argyllshire, Sept. 28, 1932 and Innellan, Argyllshire, Sept. 29, 1932, G. D. Darker (II); Holne Chase, Ashburton, Devon, Apr. 19, 1934, L. M. Hunter (II, III); Glendhu, Glencullen, Dublin, Mar. 29, 1934, H. B. S. Montgomery (II, III); Killakee, Dublin, May 19, 1934, P. O'Connor (II, III); Woodfalls Cross, Downton, Hampshire, Nov. 14, 1933, L. Allen and L. M. Hunter (II); Blackdown, Haslemere, Surrey, Dec. 11, 1933, R. Blockey and L. M. Hunter (II).

Milesia carpatica (Wrób.) Faull on *Dryopteris Filix-mas* (L.) Schott.: Milber Wood, Newton Abbot, Devon, Jan. 1, 1934, L. M. Hunter (II); Milber Wood, Newton Abbot, Devon, Apr. 6, 1934, L. M. Hunter (II, III).

Milesia Kriegeriana (Magn.) Arth. on *Dryopteris Filix-mas*. (L.) Schott.: Benmore Estate, Argyllshire, Sept. 28, 1932, G. D. Darker (II); Milber Wood, Newton Abbot, Devon, Jan. 1, 1934, L. M. Hunter (II); Torquay, Devon, Mar. 25, 1934, E. Milton (II, III);

Watcombe Glen, Torquay, Devon, Apr. 8, 1934, L. M. Hunter (II, III); Powerscourt, Wicklow, May 20, 1934, P. O'Connor (II, III).

Milesia Kriegeriana (Magn.) Arth. on *Dryopteris spinulosa* (O. F. Müller) Kuntze: Benmore Estate, Argyllshire, Sept. 28, 1932, G. D. Darker (II); Duloe, Liskeard, Cornwall, Mar. 31, 1934, M. P. Hall (II, III); Watcombe Glen, Torquay, Devon, Apr. 8, 1934, L. M. Hunter (II, III); Powerscourt, Wicklow, May 6 and 20, 1934, P. O'Connor (II, III).

Milesia Kriegeriana (Magn.) Arth. on *Dryopteris spinulosa* var. *dilatata* (Hoffm.) Underw.: Milber Wood, Newton Abbot, Devon, Jan. 1, 1934, L. M. Hunter (II); Milber Wood, Newton Abbot, Devon, Apr. 6, 1934, and Holne Chase, Ashburton, Devon, Apr. 19, 1934, L. M. Hunter (II, III); Killakee, Dublin, May 19, 1934, P. O'Connor (II, III); Woodfalls Cross, Downton, Hampshire, Nov. 15, 1934, L. M. Hunter (II).

Milesia murariae (Magnus) Faull on *Asplenium Ruta-muraria* L.: Clonsilla, Dublin, Apr. 24 and May 1, 1934, P. O'Connor (II); Powerscourt, Wicklow, May 6, 1934, P. O'Connor (II).

Milesia Polypodii B. White on *Polypodium vulgare* L.: Innellan and Sandbank, Argyllshire, Sept. 29, 1932, G. D. Darker (II); Marldon, Torquay, Devon, Dec. 31, 1933, L. M. Hunter (II); Berry Pomeroy, Torquay, Devon, Apr. 2, 1934 and Marldon, Torquay, Devon, Apr. 23, 1934, L. M. Hunter (II, III); Annahilt, Hillsboro, Down, Aug. 25, 1934, L. M. Hunter (II); Glencullen, Dublin, Apr. 1, 1934, H. B. S. Montgomery (II); Powerscourt, Wicklow, May 6, 1934, P. O'Connor (II, III); Woodfalls Cross, Downton, Hampshire, Nov. 15, 1933, L. Allen and L. M. Hunter (II); Blackdown, Haslemere, Surrey, Dec. 11, 1933, L. M. Hunter (II).

Milesia Scolopendrii (Fuckel) Arth. on *Scolopendrium vulgare* Smith: Duloe, Liskeard, Cornwall, Mar. 31, 1934, M. P. Hall (II, III); Cockington, Torquay, Devon, Dec. 28, 1933, L. M. Hunter (II); Torquay, Devon, Mar. 25, 1934, E. Milton (II, III); Bishop's Walk, Torquay, Devon, Apr. 1, 1934, and Watcombe Glen, Torquay, Devon, Apr. 22, 1934, L. M. Hunter (II, III); Glencullen, Dublin, Apr. 1, 1934, H. B. S. Montgomery (II); Hale, Downton, Hampshire, Nov. 14, 1933, L. Allen and L. M. Hunter (II); Powerscourt, Wicklow, May 20, 1934, P. O'Connor (II, III).

Milesia vogesiaca (Syd.) Faull on *Polystichum angulare* Presl.: Killakee, Dublin, May 19, 1934, P. O'Connor (II, III).

Milesia Whitei Faull on *Polystichum angulare* Presl.: Watcombe Glen, Torquay, Devon, Apr. 8, 1934, and Lincombe Hill, Torquay, Devon, Apr. 23, 1934, L. M. Hunter (II, III); Powerscourt, Wicklow, May 20, 1934, P. O'Connor (II, III).

The uredospore and the teleutospore stages as indicated, of the

following species of *Milesia*, are reported for the first time from England and Ireland:

England: *M. Blechni* (III); *M. carpatica* (II, III); *M. Kriegeriana* on *Dryopteris Filix-mas* (III); *Milesia Polypodii* (III); *M. Whitei* (III).

Ireland: *M. Blechni* (III); *M. Kriegeriana* on *Dryopteris Filix-mas* (II, III); *M. Kriegeriana* on *Dryopteris spinulosa* (II, III), *Milesia murariae* (II); *M. Polypodii* (III); *M. Scolopendrii* (III); *M. Whitei* (II, III).

SOME NEW BRITISH RECORDS OF FUNGI ON WHEAT

CERCOSPORELLA HERPOTRICHOIDES FRON., *GIBELLINA CEREALIS* PASS., AND *OPHIOBOLUS HERPOTRICHUS* (FR.) SACC.

By MARY D. GLYNNE

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1. *Cercosporella herpotrichoides* Fron., considered one of the most important of the fungi causing foot rot of wheat in certain parts of France (3, 4) and of the United States (10), and recently recorded in Germany (8), Holland (6), and Denmark (5), has this year been found at Rothamsted.

Pale lesions with dark borders were noticed occasionally on leaf blades and more often on the outer sheaths and leaf bases of wheat on Broadbalk field and an adjacent plot in February. By the latter half of March many plants still had only the outer leaves and sheaths affected, but the fungus was also found on dead leaves, dead tillers and even dead plants and appeared to be responsible for the damage. Dark-bordered lesions were observed at the bases of sheaths and culms in April and May, and were obvious at harvest in August. The disease was fairly common and was found on every plot on Broadbalk field where wheat has been grown every year since 1843. It was found occasionally but not commonly on some of the other fields in which wheat is grown in rotation with other crops. This accords with the general view that the disease increases when inadequate rotation is practised.

Material consisting of dark-bordered leaf and sheath lesions, of dying tillers and dying plants collected several times in the latter half of March all produced abundant spores in damp chambers in a few days. Hardly any spores were obtained from similar material collected at intervals subsequently. This suggests that the duration of sporing may be very short or only possible under particularly limited external conditions.

The spores are hyaline, slightly curved, wider at one end than the other, and attached singly or less often in pairs by their larger ends. They are two- to several-septate, generally five to seven. Measurements of twenty spores showed a variation of 31–80 × 2·2–3·3 μ with an average of 59 × 2·3 μ. These fall within the limits given by Sprague and Fellows (10) of 30–80 × 1·5–3·5 μ, most spores being 40–60 μ long.

Cultures from spore suspensions grew on potato dextrose agar at 25° C. first as hemispherical mounds of grey velvety mycelium with a pale edge, later growing out over the agar rather slowly and becoming darker on the under surface. They agreed in appearance with cultures of *Cercosporella herpotrichoides* Fron., obtained from the Centraalbureau voor Schimmelcultures, Baarn, representing isolations by Foëx in France and Oort in Holland.

2. *Gibellina cerealis* Pass., which causes the "white straw disease" in wheat, was found in May on Hoos field, Rothamsted, in the plot on which wheat has been grown alternately with fallow without manure since 1856. The crop was very thin and poor and had suffered much from attack by wheat bulb fly. The fungus caused rotting of tillers and stunting of shoots. It is characterised by dark-bordered elongated lesions on the lower leaf sheaths and basal parts of the culms with a greyish white mycelial felt penetrating and uniting the leaf sheaths, and developing into a stroma with darker cells below. Numerous pale perithecia with black protruding beaks were embedded in the stroma. Only one or two were ripe at the end of May, but from June onwards ripe perithecia were common on affected plants.

Measurements (ten perithecia) showed a variation of 315–600 × 285–570 μ with an average of 432 × 395 μ for the perithecium and 285–455 × 125–220 μ with an average of 367 × 159 μ for the beak. There were numerous filamentous paraphyses among the asci which measured (twenty asci) 90–125 × 13–18 μ with an average of 105 × 16 μ. The uniseptate spores arranged in two rows in the ascus were hyaline at first, becoming honey coloured to hazel and rarely 2–3 celled. Twenty spore measurements showed a variation of 23–36 × 7–11 μ with an average of 30 × 9 μ. Except in the width of the asci these measurements more than cover the range given for *Gibellina cerealis* Pass. Comparison with No. 3669 Rabenhorst-Winter, Fungi europaei, collected by Passerini (Herbarium, Royal Botanic Gardens, Kew) indicate that it is the same fungus.

Germination of spores was not observed, and Ferraris[2] states that they take a long time to mature. Cultures made from the mycelium, however, grew on potato dextrose agar at first as white mounds which later sometimes turned pale grey. Numerous perithecia developed both in the medium and in the aerial mycelium producing asci with typical honey coloured spores in cultures about five weeks old.

The disease was recorded by Passerini[7] in 1886 in Northern Italy, and has recently been noted by Ferraris[2] as occasionally appearing in May doing slight damage. As crop rotation is unfavourable to the disease and is practised in Italy he considers the disease unlikely to become prevalent. Sprague[9] reports it on winter wheat and oats in Oregon, where it occurs locally on some red

sandstone-shale soils, acid in reaction, in the humid coastal regions. He found only immature perithecia and supposes that the dry summers of Oregon are not favourable for their maturation.

3. *Ophiobolus herpotrichus* (Fr.) Sacc. Ripe perithecia were found in March on wheat stubble that had over-wintered in the soil, but no evidence of parasitism was obtained. The perithecia are black with a conical curved beak; the ascospores needle-shaped, multi-septate, measuring (twenty spores) $123-190 \times 2 \cdot 2 \mu$ with an average of $155 \times 2 \cdot 2 \mu$. Cultures on potato dextrose agar are whitish grey or brownish, often with dark and light areas. As they become older the under surface becomes darker and ultimately black. The fungus occurs in several European countries together with other fungi causing foot rot of wheat and is generally regarded as a weak parasite of secondary importance. In America[1] it has been found on *Agropyron repens* (L.) Beauv. but not on cereals. In Great Britain it has also been recorded on wild grasses, but not previously on cereals.

I wish to record my thanks to Miss E. M. Wakefield for help in the identification of these fungi.

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CYLINDROSPORIUM CONCENTRICUM GREV.

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(With 8 Text-figures)

INTRODUCTION

In 1823 Greville described a fungus producing white spots on cabbage leaves. It was first discovered in a garden at Parson's Green, near Edinburgh, but Greville remarks: "It does not seem to be very rare as I have noticed it in various localities since and probably few gardens will be found without it at some time or other of the year." Unfortunately he gives no more precise information as to the distribution of the fungus at that time.

For the reception of this fungus Greville founded the genus *Cylindrosporium*, with the following characters:

Very minute plants, parasitic on living leaves, without rupturing the epidermis. Sporidia cylindrical, truncate, jointless, naked, free, forming little heaps.

The species he called *C. concentricum* and described it as follows:

Very white and excessively minute but sufficiently conspicuous from their number and from being disposed in concentric lines. Form most irregular; frequently oblong, lying in the direction from the centre to the circumference, projecting into angles and little eminences and having often one extremity turned up like the end of a canoe. Sporidia very numerous, cylindrical, truncate at both extremities, pellucid without joints and not furnished with any membrane or covering whatever. Turning in decay to a dirty yellow, which always commences in the centre, while new individuals are forming at the circumference. The peculiarity of its cylindrical sporidia, and its situation on the surface of living leaves, fully entitle it to generic distinction.

In 1849 the genus *Gloeosporium* was founded by Montagne. Into it he put the species previously included in *Myxosporium* and *Asteroma* and several new species.

During this time there seems to have been some doubt about Greville's fungus, and there is no record of anyone except Greville having collected it. In 1850, however, it appeared in abundance in market gardens in Northamptonshire. Berkeley[1] immediately recognised it as Greville's fungus and took the opportunity of examining fresh material. He described the fungus as follows:

The parasite forms, both upon the upper and under surface of the leaf, roundish often confluent patches, varying greatly in size, consisting of little white specks disposed more or less concentrically, those of the centre frequently becoming yellow, and at length fading away, in consequence of the partial decomposition of the leaf which they have affected, while the outer pustules spread from the circumference to the part yet remaining healthy. Occasionally they extend to

the midrib, which is then rapidly destroyed. On close examination it is found that the fungus, each speck forming a distinct individual, is produced between the true cuticle and the cuticular cells.... The cuticular cells, however, are much confused and deranged by the growth of the parasite, which is developed principally at their expense, those of the succeeding layer being very little if at all affected. The mycelium is closely incorporated with the cuticular cells, and appears simply grumous, without distinct structure;... it does not appear to be filamentous. From the top of this mass, on the level of the tips of the cells on which it grows, arise very short delicate sporophores, each of which is surmounted by an oblong, cylindric, often curved, spore, three to five times as long as broad, and containing at maturity from two to three globose nuclei. It is highly probable that each sporophore produces in succession several spores, which are thus pushed forward and in time fill the space between the true cuticle and the cuticular cells, thrusting the former out until it bursts. Partly owing to the successive development of the spores, which are mixed with a viscid fluid, and partly to the contraction of the leaf itself upon the pulpy mass, in dry weather the spores ooze out, kept in connection with each other by their attendant mucilage, and drying as they are exposed to the air, form rude irregular short tendrils. These tendrils are in their turn softened again by moisture, and after a time fall down, forming a little pellicle on the leaf, the edges of which are often turned up like a little boat or canoe, as observed originally by Dr Greville. The spores, it should be observed, are not truly truncate, as they appeared to Greville when examined by the old imperfect compound microscope, but rounded and obtuse.

Berkeley considered that Greville was correct in founding a new genus, but that *Cylindrosporium* was identical with *Gloeosporium*. He added:

It is but proper courtesy to adopt his (Montagne's) name unless he should think fit to restore that of Greville as to the identity of which there is now no doubt.

It was therefore proposed that the fungus should be called *Gloeosporium concentricum* Berk. & Br.

Saccardo(6) adopted Berkeley's suggestion, though expressing some doubt about it, and in his *Sylloge Fungorum* Greville's fungus is given as *Gloeosporium concentricum* (Grev.) Berk. & Br. (= *Cylindrosporium concentricum* Grev.). He said that: "From Greville's figure it appears to be a doubtful species."

Considerable confusion has arisen as to the genus *Cylindrosporium* and it is difficult to trace its history. The first to use Greville's name was Unger, who added parasites on the celandine and on *Brassica* spp. under the impression that they were of the same genus as Greville's fungus. These fungi had filiform spores and it is difficult to understand how this confusion arose, for, though Unger probably never saw Greville's actual specimen, he must have seen his description. When Berkeley removed *C. concentricum* Grev. to the genus *Gloeosporium* he realised that Unger's genus was quite distinct from Greville's.

Saccardo(6) gave a clear definition of *Cylindrosporium* Ung. which might have been expected to prevent any confusion. He defined it as a *Gloeosporium* with filiform conidia and certainly a conidial stage

of *Entyloma*. Unfortunately, according to Diedicke(3) and von Hoehnel(5), some of the species included by Saccardo were not conidial stages of *Entyloma*, and other species, not *Entyloma* forms, have been added since.

In 1924 von Hoehnel(5) investigated the thirty-three species then attributed to *Cylindrosporium* Ung. em. Sacc. (non Grev.). He found that they could be divided into two groups—Melanconieae species and Sphaeroidiae species, the former including conidial forms of *Entyloma* and *Doassansia*. The species were all removed to other genera, five of which were new.

Having demolished the genus *Cylindrosporium* Ung., von Hoehnel proposed to re-establish the genus *Cylindrosporium* Grev. with *C. concentricum* as its only species. While this attitude may be tenable, the reasons which von Hoehnel gives for adopting it seem rather flimsy, especially as he had never seen a specimen of the fungus.

Von Hoehnel says: "Dieselben (Berk. & Br.) fanden, dass der Pilz, entgegen der Angabe Grevilles, sich unter der Kutikula wie ein *Gloeosporium* entwickelt und stellten daher den Pilz in diese Gattung. Unter Kutikula ist hier wohl die Epidermis zu verstehen."

This refers to a short note(2) on Greville's type specimen, and it is obvious that he cannot have seen Berkeley's paper(1) published a year later (quoted above). His description of the fungus differs from Greville's in only one point—the spores are described as having rounded ends while Greville described them as truncate. Moreover, Berkeley was particularly emphatic as to the position of the acervulus —"between the true cuticle and the cuticular cells"—so that the question of confusion between cuticle and epidermis does not arise.

Ignoring Berkeley and Broome's description, von Hoehnel's conclusion is based on that of Greville which is accepted as being correct. From the habit of the fungus, its snow white fructifications and the probable formation of the spores in loose chains, he concludes that it could not be a *Gloeosporium*. The catenulate arrangement of the spores is deduced from Greville's statement that the spores are truncate, which was denied by Berkeley. It must be admitted, however, that from Greville's inadequate description alone it would be difficult to state definitely that it was not a *Gloeosporium*.

Further, von Hoehnel says: "Greville nennt den Pilz eine sehr ungewöhnliche Pflanze, was er gewiss nicht gesagt hätte, wenn es sich um ein *Gloeosporidium* gehandelt hätte." But the genera *Gloeosporium* and *Gloeosporidium* were not established till many years after Greville's time and it may be presumed that fungi of that type were not then well known.

INVESTIGATION

A fungus forming white spots on cabbage leaves is fairly common in gardens in the Edinburgh district and can frequently be seen on the outer leaves of cabbages exposed for sale in the town. It is generally assumed to be *Gloeosporium concentricum* (Grev.) Berk. & Br. Inquiries have shown that its distribution is fairly general in Scotland and England, though nowhere abundant. Cauliflowers and broccoli are also attacked. The type specimen of Greville's *Cylindrosporium concentricum* is in the herbarium of the Royal Botanic Garden, Edinburgh. It was decided to investigate the fresh material and the type specimen and to find what relation, if any, there was between them.

Fresh material

Fresh material was easily obtained in October. The fungus forms white spots on either surface of the leaf, but more commonly on the under surface. The spots are grouped in concentric circles and each group is from 1 to 2 cm. in diameter (Fig. 1). They appear generally
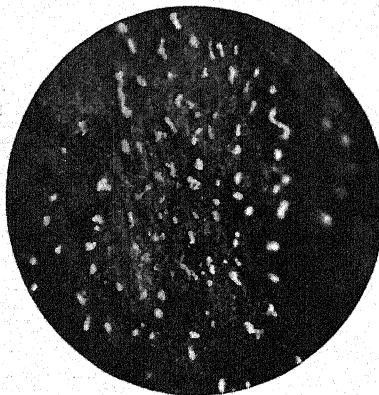
Fig. 1. Group of fructifications on cabbage leaf. × 5.

between the main veins, but may also be found on the veins. As new spots are formed on the outside of the group, the spots in the centre disappear and the leaf turns yellow and then black, and finally only a number of concentric black lines is left. Each group of spots is quite distinct, but the groups may run into each other and overlap. The fungus is found on the outer leaves, which are already beginning to yellow, and seems to have no serious effect on the host. A cabbage which had its outer leaves infected was kept under observation. Some of the adjacent leaves became infected, turned yellow and dropped off, but infection never reached the heart. Finally the fungus dis-

appeared altogether and the cabbage appeared perfectly healthy and very vigorous. The fungus can live saprophytically on dead leaves. As cabbages grow at all times of the year there is no difficulty in the fungus finding a host.

The spots are minute, being less than 1 mm. across. Under the lens, a spot appears as an irregular gelatinous white mass oozing from a slit in the surface of the leaf. This exudation sometimes takes the form of a tendril, but more generally the spots are irregular and may take the form of a canoe, as described by Greville (Fig. 2).
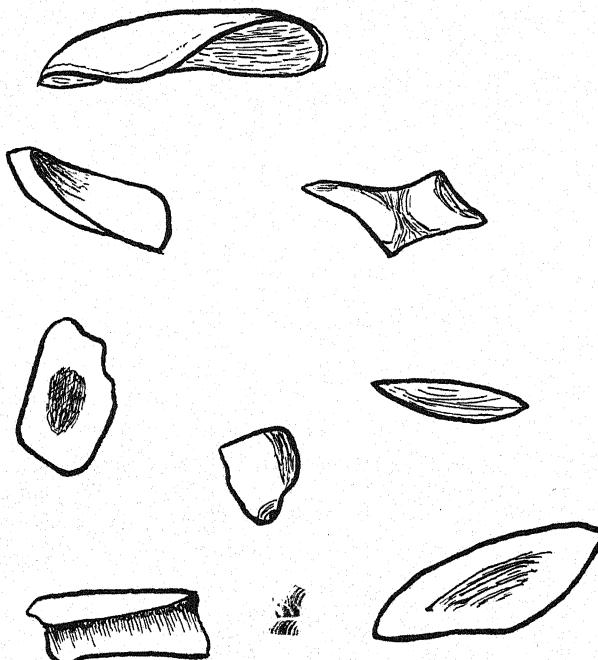
Fig. 2. Fructifications (spots) as seen on leaf surface. × 40.

While the white spots appear to ooze out of a slit in the leaf surface, there is no apparent rupture or tearing of the epidermis.

Each spot consists of a mass of spores. The spores are cylindrical, sometimes curved, with rounded ends and generally two oil drops. They are $8 \cdot 5 - 15 \times 2 \cdot 5 - 5 \cdot 5 \, \mu$, with an average size of $11 \times 4 \, \mu$. In January spores were found with an irregular number of transverse bands. This was due to enlargement of the oil drops and the formation of the protoplasm into bands between them (Fig. 3).

Sections were cut of infected leaves. In section the fructification appeared as an irregular grumous mass surmounted by a heap of

spores (Fig. 4). The position of the spores in irregular chains suggested that they were budded off in succession from the basal hyphae, though no section could be obtained showing the process of budding. Where the lamina was infected the tissues were somewhat disorganised, but
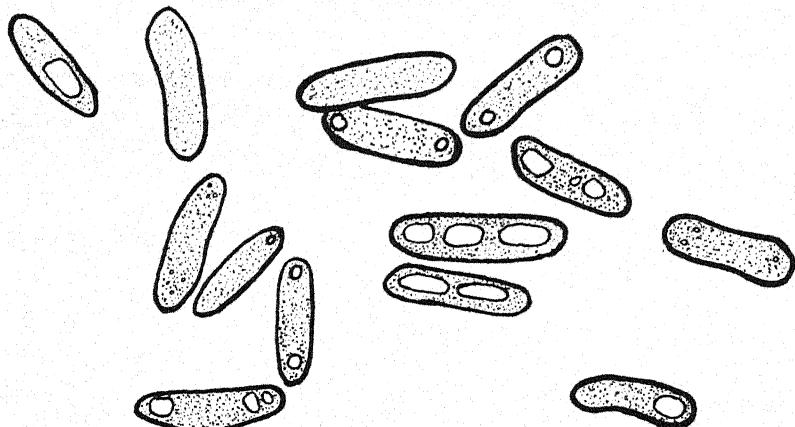
Fig. 3. Spores. × 3600.
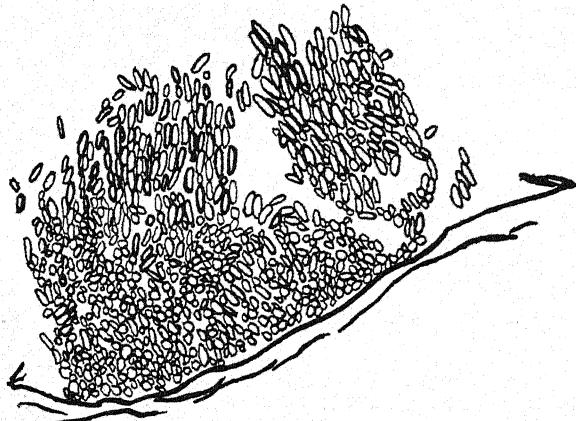
Fig. 4. Section of fructification from leaf lamina. × 360.

the fungus was obviously superficial. Sections through fructifications over a vein, however, showed that they were subcuticular, and no trace of penetration through the epidermal walls could be found (Fig. 5). Sections were obtained showing hyphae within the cuticle between fructifications. The hyphae appeared singly or in pairs, but

occasionally several were clumped together and may have repre-
sented a young fructification (Fig. 6).

It will be seen that this fungus agrees exactly with Greville's
description (as far as it goes) of *Cylindrosporium concentricum*, except
for the form of the spores which Greville gave as truncate. This
difference, however, was plausibly explained away by Berkeley (see
p. 124). It also agrees with Berkeley's description, though no definite
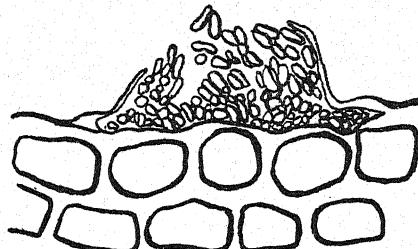
Fig. 5. Section of fructification from vein, showing subcuticular position. × 360.
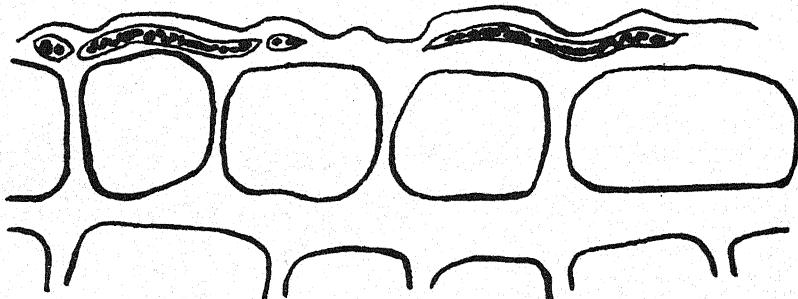
Fig. 6. Section of epidermal cells, showing hyphae within cuticle. × 1270.

sporophores could be found. Berkeley figured the sporophores but
does not show them in his figure of the acervulus. This figure shows
a flat layer of fungal tissue surmounted by a single layer of spores
with no definite attachment. A very similar appearance is seen in
hand sections of the fresh material in which the upper spores are
knocked off leaving only a single layer.

Saccardo described *Gloeosporium concentricum* as having truncate
spores, and this is the only point of difference between his description
and the fungus examined.

There can be no doubt that this fungus and Greville's are identical.

Type specimen

The type specimen bears the legend "*Cylindrosporium concentricum* nov. gen. mihi. On *Brassica oleracea*. Balmuto [Fife], May 1822. Miss Boswell". It consists of a small piece of cabbage leaf with pale-coloured areas but showing no external signs of the fungus.

Sections were cut and fructifications were found. They were quite similar to the fructifications on fresh material, but flattened out owing to herbarium treatment (Fig. 7). Owing to the disorganisation of
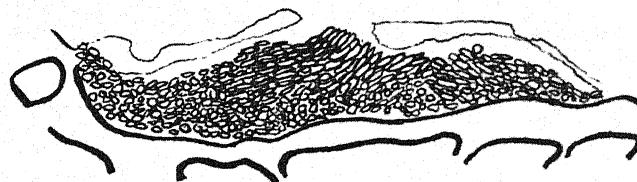
Fig. 7. Section of fructification from Greville's type specimen. × 360.

the tissues it was impossible to determine their exact position, but they appeared to be superficial. Free spores could not be obtained so the spores were measured in the sections and compared with spores in sections of the fresh material after similar treatment:

	Type specimen	Fresh material
Spore size range	5·5–8·0 × 1·6–2·5 μ	5·5–8·0 × 1·6–2·2 μ
Average	6·6 × 2 μ	6·6 × 2 μ

It should be noted that the spores are not truncate but have rounded ends. There is a co-type specimen in the Kew Herbarium and free spores have been obtained from it. These spores show this character very clearly.

This investigation of the type specimen confirms the conclusion that the fungus found on the cabbage and Greville's fungus are identical.

Cultures

Spores from fresh material were germinated in water and dilute cabbage extract. They germinated by a single terminal or sub-terminal germ tube.

Attempts to culture the fungus on malt and oatmeal agar failed. The spores germinated but soon died off. A medium was therefore made up with cabbage extract. 200 gm. of fresh cabbage leaves were boiled in water for 7½ hours, the extract filtered and made up to 200 c.c. The best results were obtained on a medium containing 5 per cent. of this extract.

The fungus grows very slowly, ultimately forming a growth 1–2 cm.

in diameter. The mycelium, which is greyish, grows within the medium, but frequently a white cottony mycelium is produced on the surface. Later, white gelatinous pustules appear, very like the spots on the cabbage leaf. These pustules consist of heaps of spores as on the cabbage.

The spores are budded off irregularly from the hyphae, there being no specialised sporophores. They are produced laterally or terminally in succession and lie loosely in irregular chains (Fig. 8).
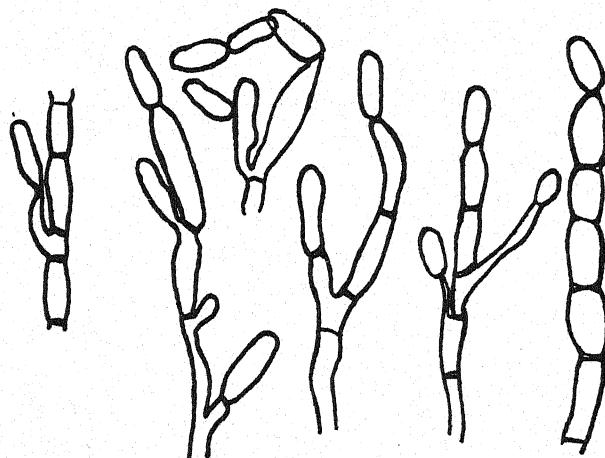
Fig. 8. Spore formation in culture. × 1800.

At a late stage small black sclerotium-like bodies may be produced in culture. They are spherical or lobed and no definite internal structure could be made out. They may possibly be immature pycnidia, but no spores could be found in them. In its final form, black radiating lines appear in the growth giving it a dark appearance, but the periphery remains grey.

DISCUSSION

The question arises as to the systematic position of the fungus. Berkeley and Broome regarded it as a *Gloeosporium* and were followed in this by Saccardo. The alternative is to retain Greville's genus *Cylindrosporium* and to regard it as monotypic as suggested by von Hoehnel. Certainly there is nothing in the description of the genus *Gloeosporium* as given by Saccardo which definitely excludes the fungus from that genus, except the subcuticular position of the acervulus, and Saccardo included it in spite of this. On the other hand, it is certainly not a typical *Gloeosporium*. The heaping up of the spores

in clumps is unusual, and there seems to be no record of another subcuticular species in the genus. *Gloeosporium* species have typically a shallow fructification bearing a shallow layer of spores, while in this fungus the spores appear to be budded off in chains and adhere together in a heap above the fructification. Cultures have shown that this arrangement of the spores is due to their being budded off in succession from the hyphae. von Hoehnel thought that its habit, the whiteness of the fructifications, and the probable arrangement of the spores in chains (deduced from the truncate spores) were sufficient to distinguish this fungus from *Gloeosporium*. While these characters alone seem inadequate, when they are combined with the subcuticular position of the acervulus, the formation of the spores by irregular budding, and the confirmation of the catenulate arrangement of the spores (though they are not truncate), there seems good reason for retaining Greville's genus *Cylindrosporium*.

SUMMARY

Cylindrosporium concentricum Grev. was described by Greville in 1823.

Berkeley removed it to the genus *Gloeosporium* Desm. & Mont., and was followed in this by Saccardo.

von Hoehnel in 1924 removed all the species from *Cylindrosporium* Ung. em. Sacc. (non Grev.) and re-established the genus *Cylindrosporium* Grev. though he had not seen Greville's fungus.

A fungus parasitic on cabbage leaves is described and compared with the type specimen of Greville's fungus. It is shown to be identical with the type specimen and to agree in external characters with Greville's description.

Cultures of the fungus were obtained.

The fungus is not a typical *Gloeosporium*. The description appears to support von Hoehnel's view that the genus *Cylindrosporium* Grev. should be re-established with this fungus as its type species.

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STUDIES IN THE GENUS *USTULINA* WITH SPECIAL REFERENCE TO PARASITISM

II. A DISEASE OF THE COMMON LIME (*TILIA VULGARIS* HAYNE) CAUSED BY *USTULINA*

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(With Plate I and 8 Text-figures)

I. INTRODUCTION

As stated in a previous communication (26), the main objective of these studies is investigation into the economic aspect of the temperate form of *Ustulina* in relation to standing timber—especially beech. Beech was chosen because the timber is important and because, in my opinion, *Ustulina*—which is characteristically abundant on that tree—causes a timber rot which is sufficiently serious to merit attention.

Under the general heading, however, the above-mentioned disease of lime. is a specific case which occurred locally, and, as it affords excellent material for relevant investigation as well as opportunity for testing experimental methods, will be considered first and is the only aspect of the problem dealt with in the present paper.

Lime is characteristically immune to any form of fungus disease and particularly so to disease of the "timber rot" type; it is not therefore surprising to find that there appear to be only six previous records of *Ustulina* on this host. The first three of these, Lind (13) from Denmark, Bizzozero (1) from Italy, and Sydow (22) from Germany, merely indicate growth of the fungus on the tree with no suggestion of parasitism. Of the last three, however, Wehmer (24), in Germany, is doubtful whether or not it causes disease; Van Overeem (23) says that it occurs in France, is emphatic that it causes disease of lime in that country, but gives no circumstantial details; while Patouillard (16), from France, definitely states that *Ustulina* is parasitic. He says*:

Ce champignon bien connu à l'état saprophyte paraît avoir causé la mort de deux troncs de Tilleul dans l'Ain, en attaquant par la base, au niveau du sol. Sur une hauteur de 20 à 30 cent. ces deux troncs étaient recouvert d'une couche continue du parasite, sauf sur une largeur de 10 cent. qui est restée saine.

Le bois est complètement envahi par le mycelium et a pris une consistance très

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* This important reference does not appear in the literature list given in Part I, as it was verified too late to be included in that paper.

molle, jusqu'au centre des arbres, en sorte qu'une simple coup de vent a pu les faire tomber.

L'Ustulina est très fréquent sur les vieilles souches voisines tant sous sa forme ascophore qu'à l'état conidifère mais toujours en saprophyte.

Dans le cas actuel il est nettement parasite.

This scarcity of previous record of disease of lime by this fungus does not entirely eliminate the possibility of its being a pathogen of economic importance as the disease may have been overlooked—a factor which I should like to suggest is also largely responsible for its non-recognition as a pathogen on beech, though this is even less understandable. A second and more probable reason is that the disease symptoms of *Ustulina* may have been credited to another fungus of the "black-line" type.

No standard text-book on the diseases of trees from the time of Hartig(8) in 1882, to the *Forest Pathology* of Hubert(12) published in 1931, makes any reference to *Ustulina* as a wood destroyer.

I have come across three lime trees which appear to have been diseased by *Ustulina*:

(1) A tree brought down by the wind in the Botanic Gardens at Oxford.

(2) The tree next to the above which is obviously infected but is still standing.

(3) A very diseased tree in Blenheim Park, Woodstock. This tree is quite hollow, shows all the signs of *Ustulina* disease, and no fructifications other than those of this fungus were found on the tree.

Of these trees only the first mentioned was available for experimental purposes.

II. Preliminary Examination of the Tree

The tree was a well-grown specimen about seventy years old, and, apart from a few dead branches, the crown appeared to be perfectly healthy. Closer examination revealed the fact that the trunk was less sound, there was a wound on the north side—caused when the tree was struck by lightning about 1880—extending from ground level to a height of about twelve feet. The exposed wood of the wound was soft and rotten, but the rest of the trunk seemed to be perfectly normal. There were no sporophores or visible fructifications of any fungus except those of the saprophytic *Peniophora quercina* (Pers.) Cke. on some of the dead branches, and those of *Ustulina vulgaris* Tul. which were growing on the surface of the exposed wood of the wound. There was no evidence of the rhizomorphs of *Armillaria mellea*.

When the tree crashed the base was badly smashed up from ground level, where it broke off, to a height of about six feet; it was apparent that, except for a few inches of sound wood on the south side, all

the base of the trunk was completely rotten, obviously diseased by fungi or bacteria. The rotten wood was soft and crumbly and thoroughly permeated by "black lines".

III. Isolation of the causal organism

By means of a borer, many sterile isolations were taken from the diseased timber in various parts of the stem and roots. The isolations were grown on media known to be favourable to the growth of most fungi and many bacteria, but all isolations produced only remarkably pure cultures of *Ustulina vulgaris*. Eventually the identity of the causal organism with this species of fungus was presumed on the following grounds:

(1) Proximity of undoubted fructifications of *Ustulina* to the diseased timber.

(2) Similarity of cultures isolated from the diseased timber with those of standard cultures of *Ustulina*. This diagnosis was confirmed by Mr Cartwright (Head, Mycology Department, Forest Products Research Laboratory, Princes Risborough), both from cultures supplied by the writer as well as from his own independent isolations from the timber.

(3) In spite of repeated trials no other fungus could be isolated.

(4) The details of the disease conditions corresponded very closely with those described, as caused by *Ustulina* on certain tropical trees, by other investigators.

(5) Artificial infection with the isolated fungus into sound lime wood produced only symptoms of disease identical with those occurring in the naturally infected wood. This was true in inoculation into dead wood as well as in artificial infection into living trees.

(6) The fungus was re-isolated from the artificially infected wood— dead and living—and again pure cultures of *Ustulina* were obtained.

(7) Artificial inoculation into lime with a culture from authentic *Ustulina* spores produced exactly the same symptoms as the above.

The invariable presence of *Ustulina* in the diseased wood does not preclude the possibility of its being a secondary rather than a primary infection, but it is suggested that the evidence produced in the course of this paper tends to disprove this hypothesis.

IV. General observations on the type and extent of the disease

(1) *Macroscopic examination*

Through the kindness of the Bursar of Magdalen College, I was able to have the whole tree for the purpose of investigation, and both stem and root were cut up into sections.

In the sections of the stem and root the so-called "sound wood"

was the normal wood of the lime, and, structurally, calls for no special comment. It surrounds the discoloured and diseased wood on all sides except that which is completely decayed out to the bark. Cultures of sterile borings from this wood produced no evidence that it contained fungus hyphae.

(a) The stem.

The base of the tree was badly smashed up when it broke off, and the first section which could be cut corresponded to a height of about six feet above ground level; other sections were cut as shown in the following table and will, in future, be referred to by these numbers:

Number of sections	...	1	2	3	4	5	6
Height in feet ...	...	6	10	12	14	15	18

Text-fig. 1, diagrams 1–6, shows diagrammatically the appearance of each of the sections cut at the above levels. The diagrams are from actual tracings of the sections reduced to one-eighth natural size. All the sections are arranged so that the side which originally faced north is uppermost. Plate I, fig. 1, shows a photograph of section 1.

In each of the first five sections, areas representing three distinct types of wood are recognisable; these three types will be referred to as: (i) sound wood; (ii) discoloured wood; (iii) diseased wood.

The sixth section—at eighteen feet—showed only the first two types. All the sections show the relative extent and distribution of the different types of wood in the trunk, and the discoloured and diseased wood will be discussed separately in greater detail.

(i) *The discoloured wood of the stem.* This is brownish red and is, there-fore, sharply marked off from the diseased wood on the one hand and the sound wood on the other, as both of these are light coloured. The line of demarcation between the discoloured wood and the sound wood is often specially emphasised by a narrow zone of the deeper colour which is found on the outer edge of the former. The successive sectioning of the trunk brought out the fact that the discoloured wood extended to a height of about twenty-four feet, *i.e.* about eight feet beyond the height actually reached by the diseased wood. In transverse section this discoloured wood shows a tendency to occupy a more or less central position in the stem, simulating heart-wood (lime is a sap-wood tree), and seems to be identical in appearance with the type of discoloration popularly known as "dark-heart", "black heart", "red heart", etc., which may exist as a physio-logical or pathological condition in all kinds of trees. It is more evident on that side of the diseased wood which is farthest from the (presumed) point of infection; this suggests that (*a*) it was present in the stem before the disease started, or (*b*) that it may have been
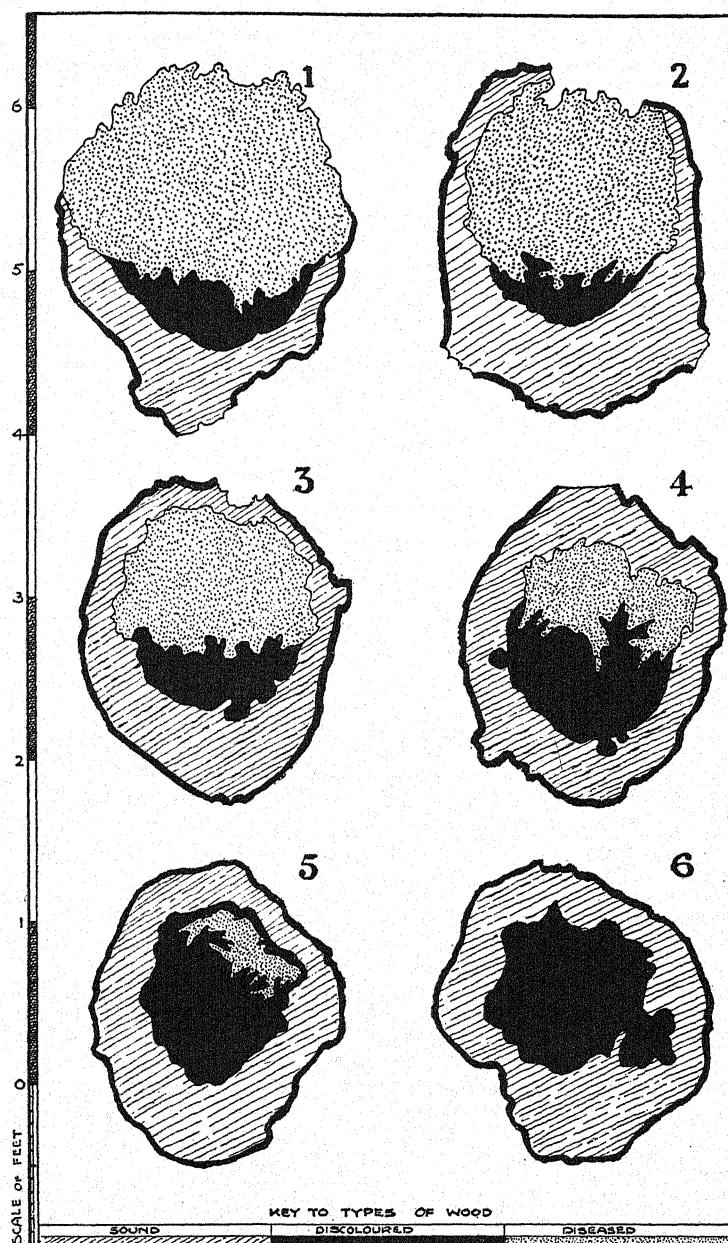
Text-fig. 1. Transverse sections of the lime stem, cut at different levels (explanation in the text).

produced by the advance mycelium of the fungus and so be a pre-liminary symptom of decay. In neither longitudinal nor in transverse section does it show any regional relation to the annual rings, but, as its outer edge tends to follow the course of the vessels, in longitu-dinal section this edge appears as a more or less straight line. In the lowermost sections it has been largely "overrun" by diseased wood and so appears merely as a comparatively narrow zone, and even this may be present at one part of the circumference only (Text-fig. 1, diagrams 1–4). In the uppermost sections it forms a relatively wider zone entirely surrounding the diseased wood (diagram 5), until, in the highest section of all, it alone occupies the central region of the stem. It seems, in fact, that the discoloured wood bears a closer relation to the stem than it does to the fungus, for its outline is more or less concentric with the outline of the stem, whereas it shows no definite relation to the outline of the diseased area.

Discoloured wood of the type mentioned above has been noted by Hubert ((11), p. 533) on a species of lime infected by *Pholiota adiposa*, and has also been referred to by Sharples ((19), p. 12) in connection with *Ustulina* disease of rubber.

Numerous sterile borings from this wood were cultured but gave no evidence that the wood contained mycelium.

(ii) *The diseased wood of the stem.* This extends up the trunk from ground level to a height of about sixteen feet. Reference to Text-fig. 1, diagrams 1–5, will show that towards the base of the tree the diseased wood occupies the greater part of the cross-section, but its area gradually decreases from the base upwards till, at a height of eighteen feet, it is no longer present; at the same time it tends to become·more centrally placed in the stem, indicating a probable preference for the older tissues or for the discoloured wood. In the transverse direction, the appearance of the diseased area suggests a progressive spread of the mycelium from the wound on the north side, and it is obvious that the disease spreads more rapidly in a longitudinal than in a transverse direction.

The diseased wood is light in weight, crumbly in texture and of a lighter colour than normal lime wood. On the more completely diseased sections—in general on sections nearer the base than the lowest section illustrated in the diagrams—the wood is typically permeated by "black lines". These are irregularly distributed and presumably make their appearance as the wood "dries out" as the result of exposure, produced naturally or artificially. They are found in wood which is on the exposed surface of the trunk but not in the diseased wood which is situated some distance from the outside. On allowing the sections to dry naturally in the laboratory, however, black lines became apparent where they had not been noticed pre-viously. They often extended across the wood more or less parallel

to and a short distance from the cut surface, and a black line was almost invariably produced (after drying out) at the junction of the diseased and the discoloured areas. The lines sometimes enclosed irregularly distributed areas of wood of a dark brown colour.

Though definitely and invariably associated with decay by *Ustulina*, these black lines are not a specifically diagnostic character, as they are present in many kinds of diseased timber, being produced by some thirty different species of fungi.

The above facts on the appearance of the diseased wood as seen by the naked eye agree in all essential details with those described for *Ustulina zonata* on rubber by Sharples[19] for Malaya, by Steinmann[21] for the Dutch East Indies, and by Weir[25] in the Amazon Valley.

As stated previously, cultures of *Ustulina* were consistently produced from sterile borings of this type of wood, though less readily from the older parts than from the region nearer to the edge of the advancing mycelium.

(b) The root.

The root system of the tree was also examined. Text-fig. 2, diagram 6, shows the general lay-out of the roots as they appeared after excavation. There was no tap root, merely a bunch of fibrous roots about three feet deep, the largest being about $2\frac{1}{2}$ inches across. The roots on the north side of the tree—from *A* to *B* on the diagram— that is to say the roots arising from below the wound on the stem, were quite rotten and broke when dug up. On the whole the roots were small; there was one large lateral root on the south side and growing towards the south, and a smaller lateral on the south-west. All these roots were infected by *Ustulina*. The largest root (south side) was sectioned as follows:

Number of section ...	1	2	3	4	5
Distance from trunk ...	9″	1′ 3″	2′ 6″	4′ 6″	5′ 3″

The root sections showed the same three types of wood as did the stem, and Text-fig. 2, diagrams 1–5, shows the relative extent and distribution of these types as seen in transverse section. As in the stem, the diagrams are from tracings of the timber, but here are reduced to quarter natural size. All the diagrams (except diagram 6) are arranged so that the morphologically upper side of the root is uppermost. Plate I, fig. 2, is a photograph of root section 1. The first two sections show all the types of wood, but on the last three sections, only sound wood and discoloured wood are represented.

(i) *The discoloured wood of the root.* From the diagrams in Text-fig. 2 it will be seen that this is particularly well represented in the root. It is rather darker in colour than the corresponding area in
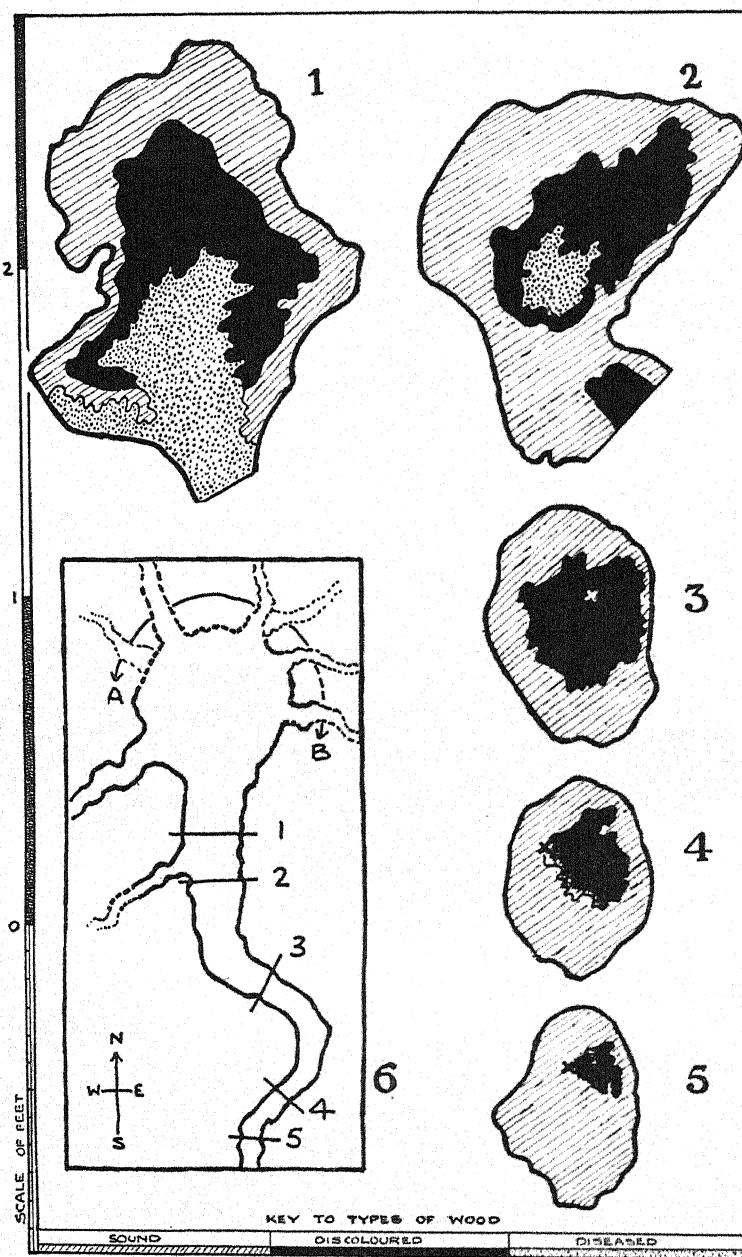
Text-fig. 2. Transverse sections of the lime root cut at different levels
(explanation in the text).

the stem—this is well shown in Plate I, fig. 2—though here the deeper colour is emphasised rather out of proportion due to the greater moisture content of the root at the time of taking the photograph—the discoloration always being more definite when the wood is damp. This discoloured wood extends down the root for a distance of about five feet six inches, *i.e.* about three feet beyond the diseased wood. It exhibits the same tendency to be restricted to the central regions that was noticed in the stem and, especially in the upper part of the root (Text-fig. 2, diagrams 1 and 2), its outline follows that of the periphery of the root sufficiently closely to suggest a physiological connection. The fact that there is no relation between the distribution of the discoloured area and the annual rings is well emphasised in the more distal part of the root—as shown in Text-fig. 2, diagrams 3, 4 and 5—where the centre of the root is marked with an *X*. Though this discoloration sometimes approaches very close to the edge (Text-fig. 2, diagram 3), yet it never extends right out to the bark.

The culturing of sterile isolations from this wood did not produce any mycelium.

(ii) *The diseased wood of the root.* There is, of course, some doubt as to the exact position of the original infection, but it would appear that the fungus travels less quickly in the root than in the stem in both the longitudinal and the transverse direction. There was no evidence of any diseased wood at two feet from the junction with the trunk, and the area of this type of wood in the cross-section of the most diseased part is comparatively small. The diseased area is found on the lowermost side of the root and, as in the stem, it spreads towards the centre. In all structural details the diseased wood of the root is similar to that of the stem. Black lines, which are not evident in the freshly cut timber, make their appearance as the wood dries out.

Sterile borings from this wood consistently produced cultures of *Ustulina.*

(c) *Distribution of disease in the tree.*

From the successive transverse sections of the stem and root and from the records obtained when these are cut longitudinally, it is possible to reconstruct the general distribution of the diseased tissues in the tree as a whole. Such a reconstruction is illustrated diagrammatically in Text-fig. 3, which is self-explanatory. This is a typical example of the effect of *Ustulina* as a wood-destroying fungus.

(d) *Superficial mycelium.*

After the sections had been cut for about a week, a dense mycelial growth appeared on the surface of certain sections of both stem and root. It grew out of the diseased wood and was never found on any
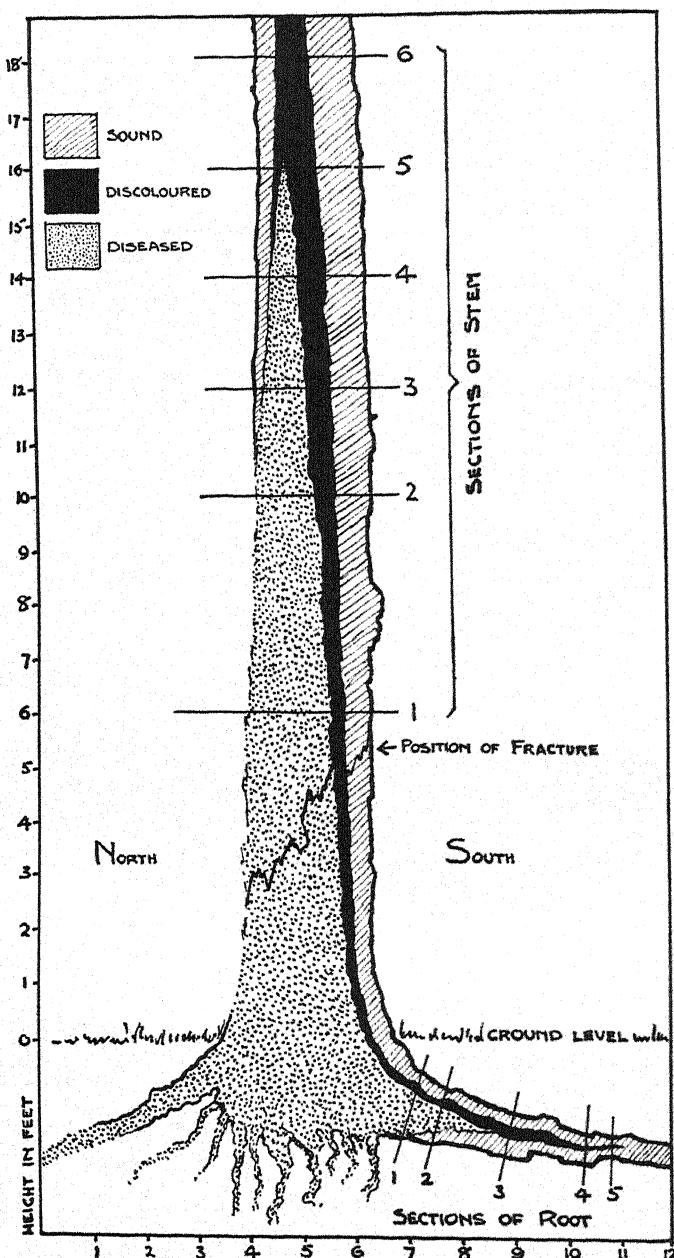
Text-fig. 3. Reconstruction of a longitudinal section through the tree
(explanation in the text).

other type of wood; the outline of this mycelium followed the outline of the diseased wood exactly. This superficial growth showed first and grew most luxuriantly on the most distal sections of stem and root, *i.e.* the mycelium seems to be most active on the growing margin. This was confirmed by observation of the transverse sections, for the fungus always appeared first on the extreme edge of the diseased wood where it bordered on the discoloured wood, the part farther from the discoloured wood showing a much more scanty growth. At a later date the mycelium was to be found on the lower sections but—in the stem—it became progressively less vigorous towards the base of the trunk, that is to say on the more completely diseased wood. Plate I, fig. 3, shows a "close up" of this superficial mycelium as it appeared on the uppermost root section. This is a typical example of the appearance of *Ustulina* mycelium as seen in nature, and this is, moreover, almost identical with its cultural aspect.

This type of superficial mycelium is figured by Schrenk ((18), Plate V) in connection with a disease of ash caused by *Polyporus fraxinophilus*, and also by Heald ((9), Fig. 246, p. 784), who shows a surface growth of the mycelium of *Stereum purpureum* on cross-section of apple timber.

(2) *Microscopic examination*

Before going on to the more detailed examination it may be well to state certain assumptions which will tend to explain the course of the investigation. In a section of the diseased trunk, *e.g.* section 2 in Text-fig. 1, it is assumed that:

(*a*) Infection took place at a point in the region of the wound on the north (uppermost) side.

(*b*) The spread of the mycelium from this point was fan-wise in the general direction of the opposite side of the stem, that is through the discoloured wood if that was already present, or converting the sound wood into discoloured wood as it penetrated it. In the latter, one is assuming discoloration to be the initial stage of decay.

(*c*) The actual decay, which proceeded more slowly, in the same sense, then gradually converted the discoloured wood into diseased wood, *i.e.* disintegration is the ultimate stage of decay.

With the idea of examining the timber from this point of view a strip about four inches wide was cut down the centre of stem-section 2. Plate I, fig. 4, shows a photograph of this strip in transverse and in radial section. The strip is arranged so that the sound wood is uppermost (the examination being carried out from the periphery inwards), and all the subsequent drawings have the same orientation.

From this strip, pieces of wood were sectioned, either by hand or by means of a wood-cutting microtome, and both before and after staining were examined and drawn.

Many stains were tried in the course of the microscopic work, but eventually it was decided that the most useful were iodine, chlor-zinc-iodine, Mäule's(14) and Cartwright's(5). The most generally satisfactory was the last named because, besides being permanent and demonstrating the fungal hyphae very distinctly, it had the additional advantage of tending to differentiate—using Mäule's stain as a criterion of comparison—between cell walls which gave a lignin reaction and those which gave a cellulose reaction, though it must be admitted that considerable experience in the use of the stain was necessary before one could be satisfied on this point. The unreliability of lignin determination by staining methods is well known, hence, in all cases of doubt Mäule's stain was used, because in the opinion of investigators such as Crocker(6), Harlow(7) and Phillips(17), etc., it is the most satisfactory. The microscope drawings were done with the aid of a Leitz projection apparatus.

In writing up this part of the work, the matter was considered under the respective headings "The effect of the fungus on the timber" and "The effect of the timber on the fungus", though considerable overlapping was unavoidable.

(a) Effect of the fungus on the timber.

(i) *The discoloured wood.* The sound wood hardly comes into this at all, so it will be well to start with the discoloured wood (see Plate I, fig. 4, B, C). This is about 1 cm. wide and is seen to consist of two regions:

(1) A peripheral zone about 5 mm. wide, dark red-brown and bordering on the sound wood. This type of wood will be referred to subsequently as "D2".

(2) The discoloured wood itself which, being very variable in width, can hardly be described as a "zone". This is of the same general colour as the D2 but less deep in tone; it will be referred to as "D1".

In both, the discoloration is largely consequent on the deep colour of the cell walls, those of the rays and wood parenchyma being yellow while those of the vessels and tracheids are red-brown. In addition to the deep colour of the walls, however, the D2 wood shows the phenomenon of occlusion of both vessels and tracheids by dark brown infiltrations. These have the superficial appearance and give the same staining reactions as the substances described by certain previous workers under the somewhat indeterminate heading of "wound gum". An interesting feature of these products is that when stained with Cartwright's stain, the products in the vessels stain blue (? cellulose complex) while those in the tracheids stain red (? lignin complex).

In the outermost half of the D2 region only the vessels are filled with these products, but in the innermost half the tracheids also are

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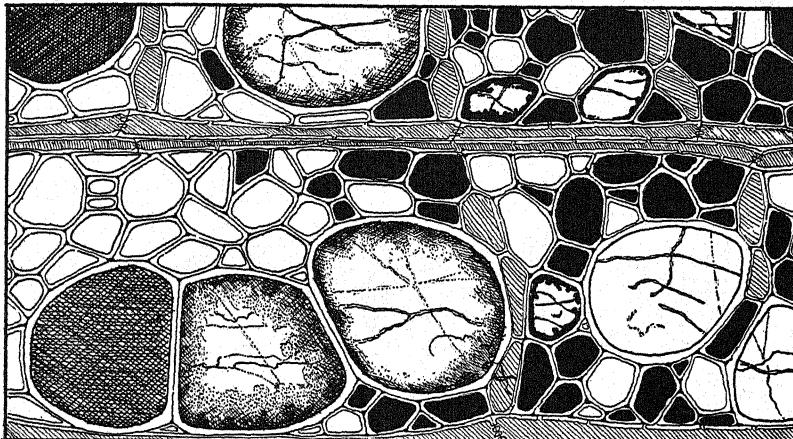
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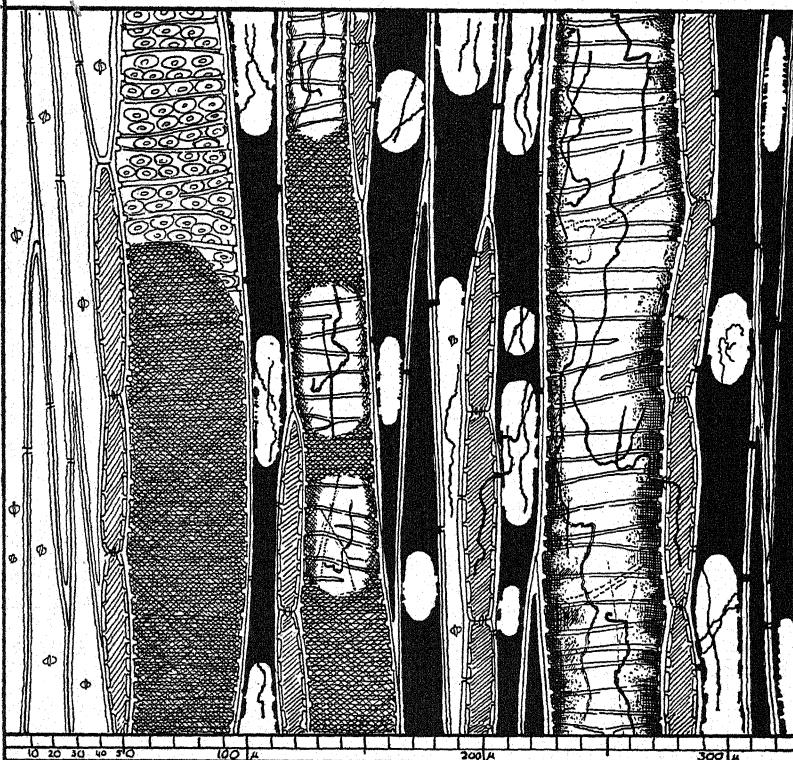
Text-fig. 4. Transverse and radial sections through the timber in the wound-gum region. The red-stained infiltration products in the tracheids are in full black, while the blue-stained products in vessels are cross-hatched.

filled; in fact, the massing of the products in this region is so abundant that practically every tracheid is filled with them. The products, though commonly found in vessels and tracheids, are comparatively infrequent in rays and parenchyma. Text-fig. 4 shows the transverse and radial appearance of this region of the wood, the blue-staining products in the vessels are cross-hatched, while the red-staining products in the tracheids are in full black. From the radial section it will be seen that the products are not continuous throughout the whole length of the tracheid but are interrupted at irregular intervals by spaces. This produces in transverse section the erroneous effect that a considerable number of the tracheids is empty. In certain vessels products are found to be adhering round the walls, while the centre is devoid of such products; these vessels invariably contain hyphae, and it is suggested that the products are probably being digested by the fungus.

The D1 wood, though having the coloured walls, does not show the filling up of the cells to any extent; occasionally cells are so filled but it is comparatively rare.

The discoloured wood of the root is essentially similar to that of the stem, except that there is less evident distinction between the D1 and D2 types of wood owing to the fact that all the cells of the D1 region of the root show a higher proportion of infiltration.

Though this discoloration may be taken to represent "incipient decay" it must, from the decay point of view, be taken as an indication rather than a fact, as the most careful examination failed to reveal any structural disintegration of the timber in the discoloured region.

(ii) *The diseased wood.* The diseased wood is delimited from the discoloured wood by the black line, as shown in Plate I, fig. 4, at C. Behind this line the wood is light in colour, crumbly in texture, and has, in fact, all the superficial characters of diseased wood. Microscopic examination, however, shows that disintegration is not a direct function of the black line itself, for actual disintegration commences about 5 mm. behind the black line. This is in agreement with the observations of Hiley ((10), p. 156) on the black line of *Armillaria mellea*, where he says "when looked at with the microscope it is remarkable how little difference can be seen in the wood on the two sides of the black line...nevertheless at some distance behind the black line marked delignification does take place". Besides the black line which is found on the edge of the diseased wood, other apparently similar lines occur scattered indiscriminately throughout the older parts of the diseased wood; as these black lines consist entirely of hyphae they will be discussed later.

The diseased wood some few millimetres behind the black line shows the first stage of decay. This decay is always more marked on

the autumn than on the spring-wood side of the annual rings. The large vessels of the spring wood appear to be unaffected; they remain intact, show no change of structure and no difference in their reaction to stains. The tracheids of the spring wood, however, are beginning to show some sign of change, their walls are thinner and less rigid than those of the sound wood, though they continue to give a lignin reaction. Below the ring, decay is more advanced; the walls of the vessels are still unaffected, but the tracheid walls have become much thinner, have lost their rigid structure and appear wavy and fragile; often there seems to be little but middle lamella left. They show evidence of considerable delignification.

In both spring and autumn wood, the rays and wood parenchyma remain apparently quite unaffected.

In very badly diseased timber, farther back from the line, the above state of affairs is emphasised; vessels, rays and wood parenchyma still show no sign of disintegration, but the tracheids of the spring wood have now reached the stage described above for the autumn tracheids, while the tracheids of the autumn wood here are completely disorganised, the walls have broken down completely and only a few scattered fragments of the middle lamella are left.

By the use of suitable stains, the course of the disintegration can be suggested. Both Mäule's and Cartwright's show when the wood fails to give a lignin reaction—the former by the absence of colour and the latter by the presence of a blue colour. It is difficult to state that the absence of the lignin reaction indicates that the delignified wall was reduced to cellulose as no cellulose indicators (such as chlor-zinc-iodine) gave a consistently positive result. The experimental use of the stains on other timbers, however, tended to indicate the probability that it was so, and this has been tentatively assumed.

Stages in the disintegration of the tracheids can be said to occur as follows:

The first stage is the appearance of delignified spots in the wall. With Mäule's stain the effect is as if a piece of the wall has been "bitten out", but Cartwright's stain shows that there is still wall substance in these spots, as, with this, they stain blue. This sort of thing develops until large parts of the wall become delignified, and often it is only at the corners that any sign of lignification remains. Eventually the whole of the wall becomes delignified and at the same time seems to be much thinner, *i.e.* it appears to collapse simultaneously with the disappearance of the lignin. At this stage the wall may lose its rigidity and become wavy or even broken. The last stage of wall disintegration is that only the middle lamella is left and finally the tracheids disappear entirely leaving an empty space surrounded by the non-disintegrated elements.

The skeleton formed by the vessels, rays and wood parenchyma

when the tracheids have disappeared, ensures that lime wood decayed by *Ustulina* always retains a certain stability even when the specific gravity is reduced to about 0·2 and the wood crumbles readily in the fingers. An example of the skeleton effect produced in a very badly decayed piece of timber is illustrated in Text-fig. 5. This also illustrates the relative frequency of fungal hyphae at this stage of decay.

(b) Distribution of the fungus mycelium in the timber.

The mycelium penetrates the whole of the diseased and the dis-coloured areas. In spite of the fact that no cultures were obtained from borings taken from the discoloured wood, microscopic examina-tion reveals the presence of hyphae in that wood. Taking the strip of wood (Plate I) in the same order as before, it is found that hyphae are first seen in the sound wood outside the discoloured area. For about 5 mm. beyond the outer margin of the discoloured wood, the hyphae are fairly abundant—though not as numerous as in the dis-coloured wood itself; and some—relatively few—hyphae are found to extend as far as 10 mm. beyond the margin. Unless otherwise stated, all the hyphae are narrow—about 1 μ in diameter.

In the D 2 zone the hyphae are fairly abundant; there are approxi-mately three hyphae in each vessel and they are rather less frequent in the tracheids. It has been stated before that in the outer part of D 2 it was only the vessels that showed decomposition products, and this would appear to be correlated with the distribution of the hyphae. In the innermost part of this region, where the tracheids also showed infiltration, hyphae are more numerous in the tracheids, but where the infiltration is very dense they are either absent or indistinguish-able. It was noticed that all vessels which had the products only round the margin of the cell invariably contained hyphae.

The D 1 region contained relatively fewer hyphae; approximately half the vessels and rather fewer of the tracheids contain about one or two hyphae each. It would appear, therefore, that there is a slightly increased development of hyphae in the outer region of the D 2 margin of the discoloured wood. In both regions hyphae were occasionally found in the rays and parenchyma.

The next region is the black line. It is usually a few cells wide, and the cells comprising it are densely filled with black contents so that the whole line appears as an amorphous mass (Brooks(2), p. 160). In thin sections, however, and particularly on the edge of the line, the "tylose" origin of these lines, as commented on by several investigators, is very obvious. This appearance is illustrated by Small ((20), Plate II, fig. 9), by Hiley ((10), pp. 155 and 157) in con-nection with *Armillaria* on larch, and by Campbell ((3), Plate III, figs. 1, 2 and 3).

In the black line no hyphae of the ordinary type could be dis-
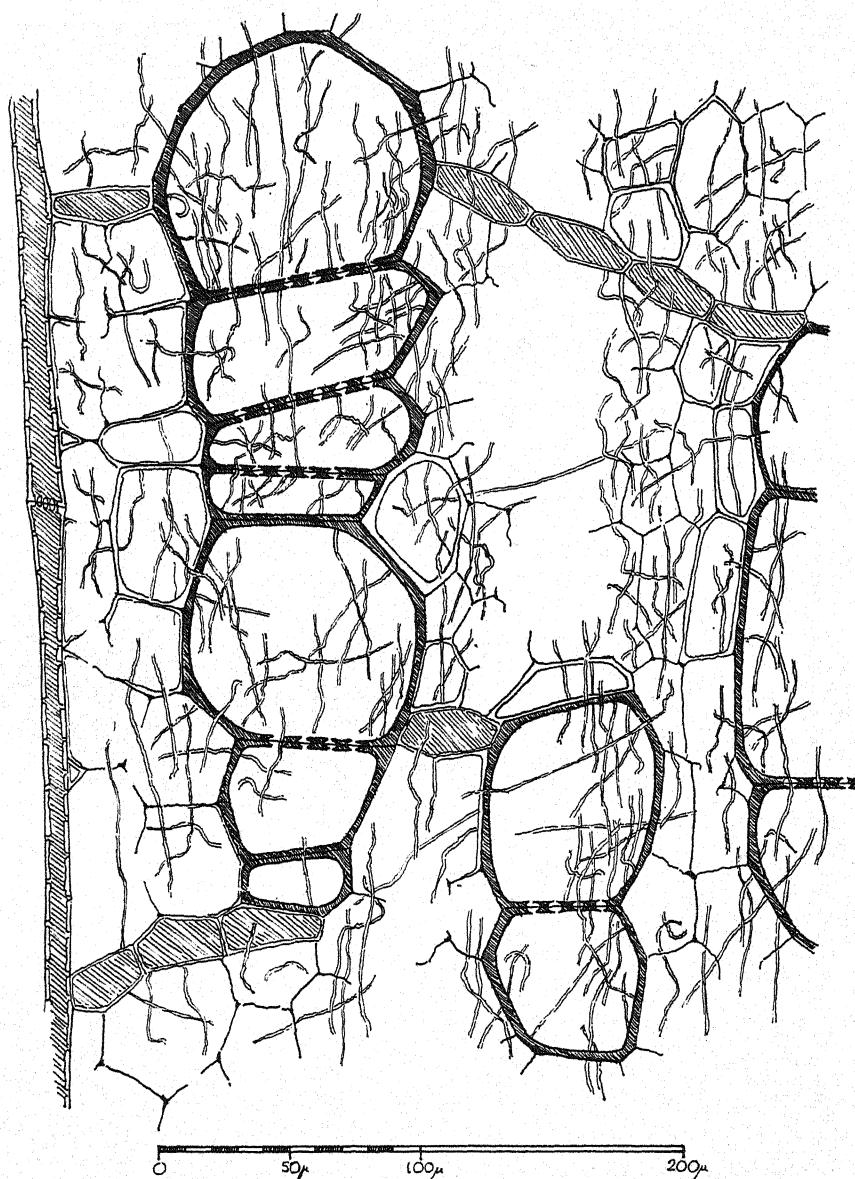
Text-fig. 5. A transverse section of a very diseased part of the timber (explanation in the text).

tinguished owing to the dense massing of the black substance. On the side of the line which is towards the discoloured wood, however, large septate hyphae—about 4 μ in diameter—appear to grow out from the black line substance, and they extend vertically up the vessels, tracheids and parenchyma for a distance of about 0·5 mm. and for approximately the same distance along the rays. These hyphae are all filled with a dark-coloured substance in the part which is nearest the line, but this discoloration gradually decreases towards the more distal parts, and the ends of the hyphae are hyaline. This state of affairs—which does not appear to have been mentioned by previous investigators—is illustrated in Text-fig. 6 which shows the transverse appearance, and particularly well in Text-fig. 7 which shows the radial appearance of the timber.

In the diseased wood behind the line, hyphae are present in large numbers; practically all the cells contain them, and sometimes the cells are literally packed with hyphae. These are all of the narrow type. Even here decay is, to some extent, localised; there may be regions where decay is slight with comparatively few hyphae, and other regions not necessarily nearer the original infection—where decay is very advanced and the hyphae extremely numerous. This type of vigorous decay may occur over a region several inches deep, but in the much older parts, where the wood is completely rotten, and has been so for some considerable time, hyphae are relatively infrequent.

Black lines also occur indiscriminately throughout the diseased wood, but, in lines which are not situated at the growing margin of the mycelium, *i.e.* at the edge where the diseased wood borders on the discoloured wood—the line merely shows the usual characteristic appearance, and there is no evidence of the above-mentioned large hyphae. Small hyphae, also, are often much less numerous in the cells associated with the black lines which are situated in the "older" parts of the decayed timber.

Previous workers have suggested that the black line is intimately connected with the process of timber decay, but, up to the present, no adequate account of the significance of the line in this connection has been produced, and I am carrying out investigations on this subject.

(c) Hyphal penetration.

In general, penetration always seems to be by means of the pits; the presence of bore holes was never detected. Nutman(15) found that, in wood subjected to the action of *Polyporus hispidus* for four months, penetration was always by means of pits; and that later penetration of vessels, rays and wood parenchyma (except in the wall bordering on the fibres) was also by means of the pits, but the fibres showed extensive penetration by bore holes.
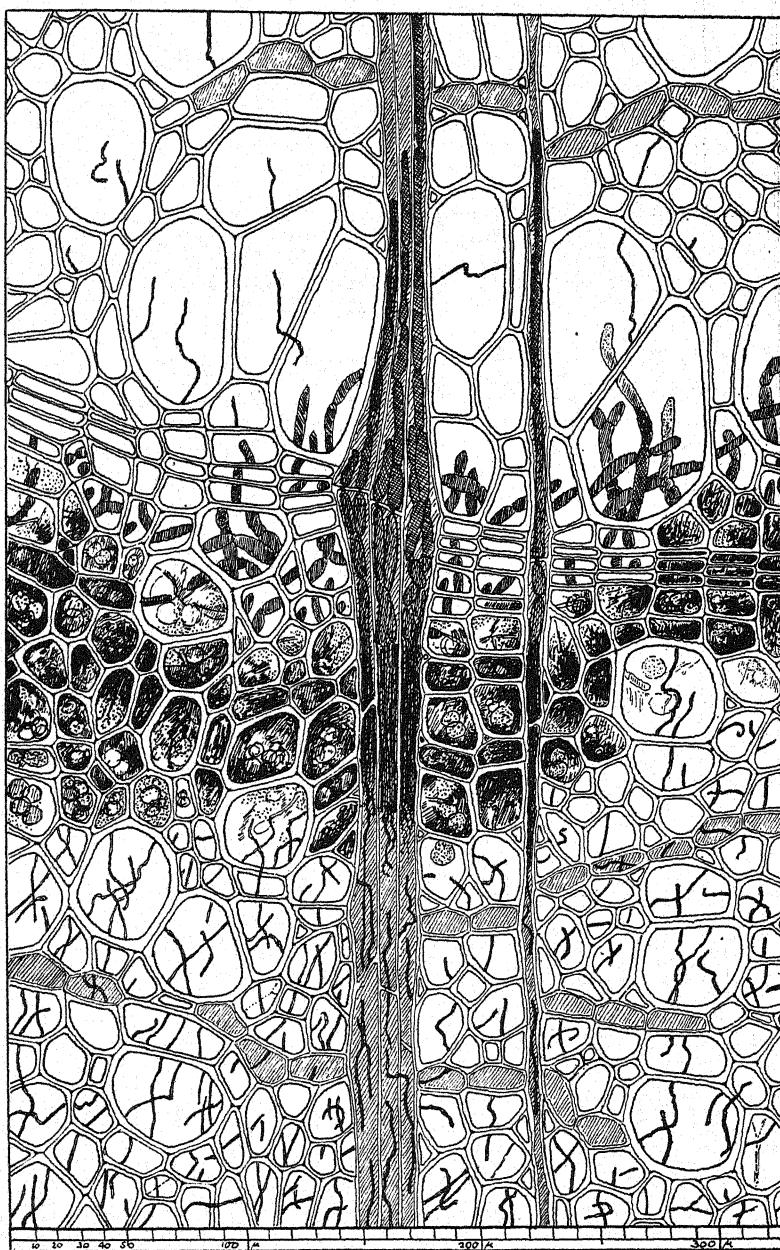
Text-fig. 6. A transverse section of the junction between the diseased and the discoloured wood, showing the black line and the relative distribution of the hyphae.
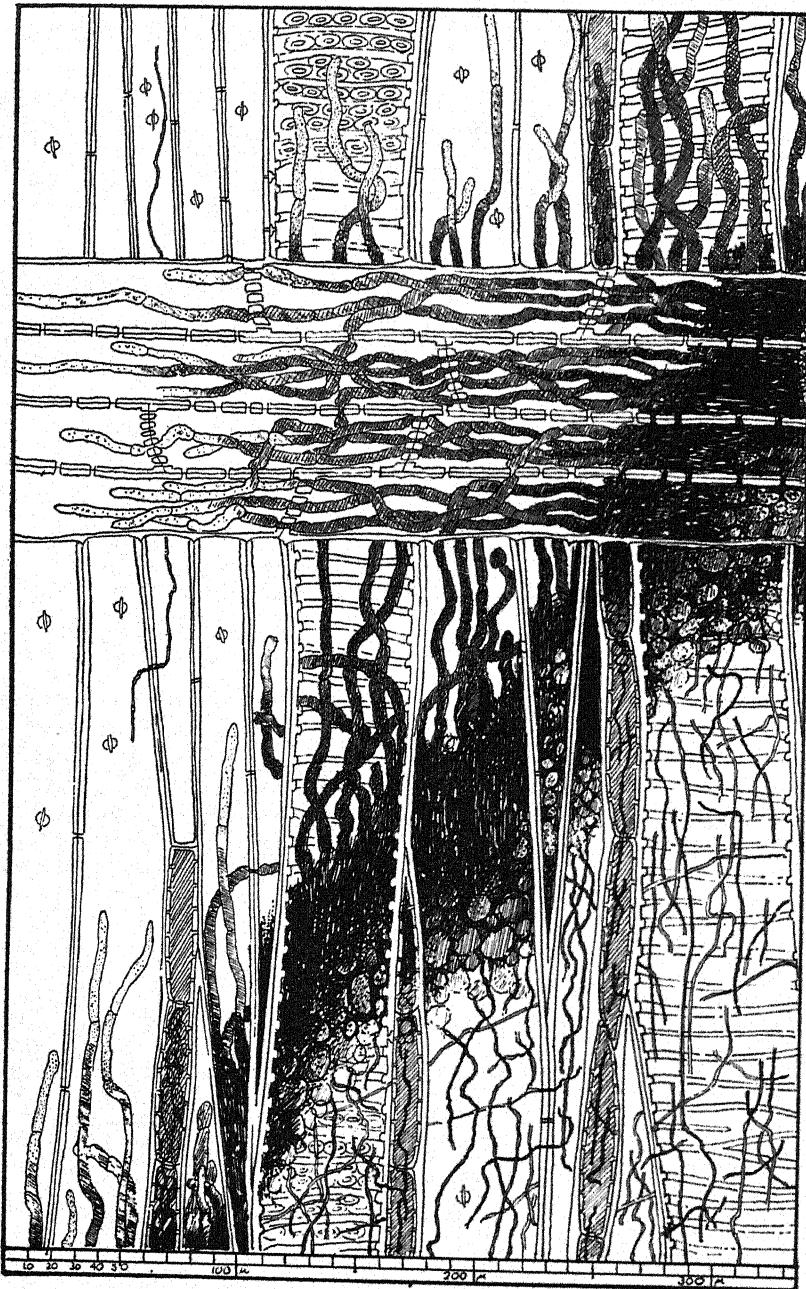
Text-fig. 7. A longitudinal section through the same region as shown in Fig. 6.

The 1 μ hyphae were about the same size as the pits and went straight through without apparent alteration. The larger hyphae, on the other hand, were sometimes constricted when they passed
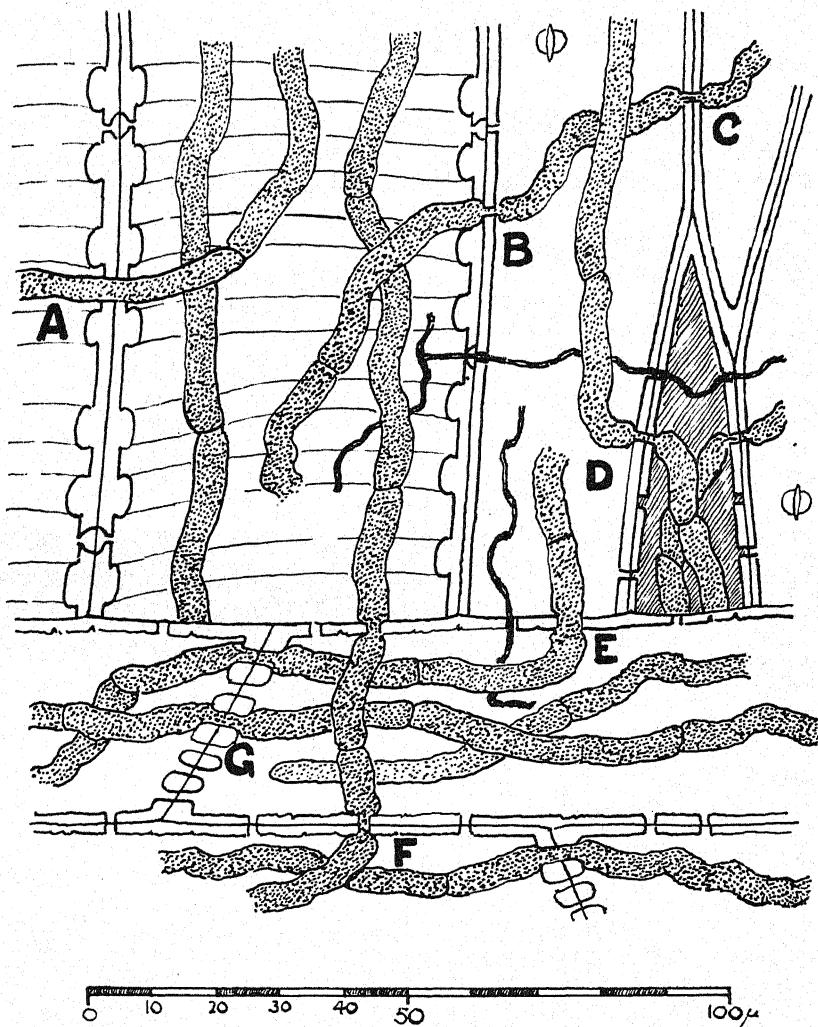
Text-fig. 8. Examples of hyphal penetration (explanation in the text).

through a pit and sometimes not, according to circumstances. Text-fig. 8 shows examples of the various types of penetration.

It will be seen that when the larger hyphae pass from vessel to vessel by means of the bordered pits, the border seems to be dissolved

away and, the pit then being about the same size as the hypha, the latter passes through without constriction (A). When passing from vessel to tracheid or from vessel to parenchyma the hypha is not constricted when it passes through the vessel wall, but is constricted when passing through the wall of the other element (B). In passing from tracheid to tracheid or from tracheid to parenchyma, definite constriction takes place (C and D). When hyphae are passing through the side walls of the rays the degree of constriction varies with the size of the pits, which themselves vary in diameter (E and F), but when passing through the end walls of the ray cells where the pits are rather large, the constriction is slight (G).

Usually the hyphae, having been constricted when passing through a pit, seem to swell up to their original size on the other side, but in certain comparatively rare instances this is not so, and the hyphae continue on the other side for some considerable distance as "narrow" hyphae. Rarely the hyphae flatten out into a disc before passing through a pit; here the actual penetration is probably of the "peg-outgrowth" type, though this has not been seen. In transverse section, the characteristic features of penetration appear essentially the same but are less easily discernible.

V. CONCLUSIONS

From the foregoing it seems reasonable to conclude that *Ustulina vulgaris* is capable of forming a very definite disease of standing lime, and from the evidence it is suggested that this fungus is to be regarded as a wood destroyer producing a white rot of the timber to such an extent that the tree may be completely destroyed and the timber reduced to a state where it has little, if any, commercial value. Speaking generally, the disease can be classified as a "white rot" and appears to belong to that type of white rot which falls into the Group II of Campbell (4), *i.e.* a white rot "in which the cellulose with its associated pentosans is attacked in the early stages and in which the incidence of the attack on lignin and the pentosans not in cellulose is delayed".

This paper deals only with the observational facts of *Ustulina* disease of a certain lime, the results of inoculation experiments and experimental work generally not yet being complete are postponed to a subsequent paper. At the moment, however, it is possible to state that all the evidence up to now tends to confirm and justify the opinion that *Ustulina* must be considered as possessing the potentialities of a pathogen of economic importance.

VI. Summary

1. A diseased lime was investigated with the object of determining the cause of disease. The only fructifications present were those of *Ustulina vulgaris* Tul.

2. The causal organism was isolated and proved to be *Ustulina*; this was confirmed by reinfection and subsequent isolation.

3. The tree was cut into sections and the extent of the disease in the stem and root was established.

4. Microscopic examination showed that the fungus attacked the cell walls of the tracheids, leaving the vessels, rays and parenchyma practically unaffected.

5. The distribution of the fungus mycelium in the timber was determined by microscopic examination and the types of fungal penetration described.

6. It was concluded that *Ustulina* causes a white rot of lime.

I am indebted to my Research Assistant, Miss E. M. Ellis, B.A., B.Sc., for valuable help in connection with this work.

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EXPLANATION OF PLATE I

Fig. 1. Transverse appearance of the lowest section of the stem, cut at a height of six feet from ground level.

Fig. 2. Transverse appearance of the first root section, cut at a distance of nine inches from the junction with the trunk.

Fig. 3. A "close-up" view of the superficial mycelium which appeared on the above root section.

Fig. 4. The transverse (left) and radial (right) appearance of a strip of timber cut down the centre of stem section 2 (explanation in the text).
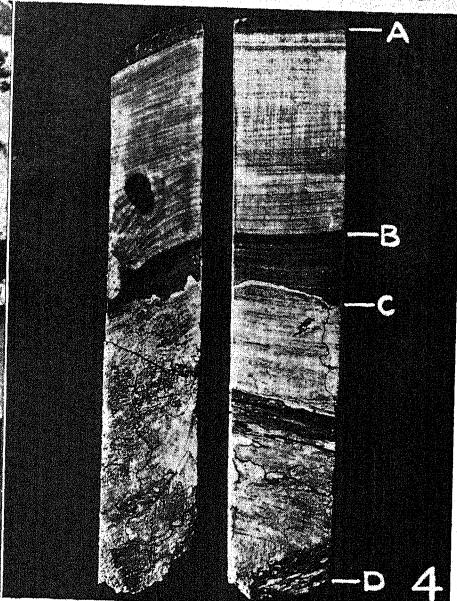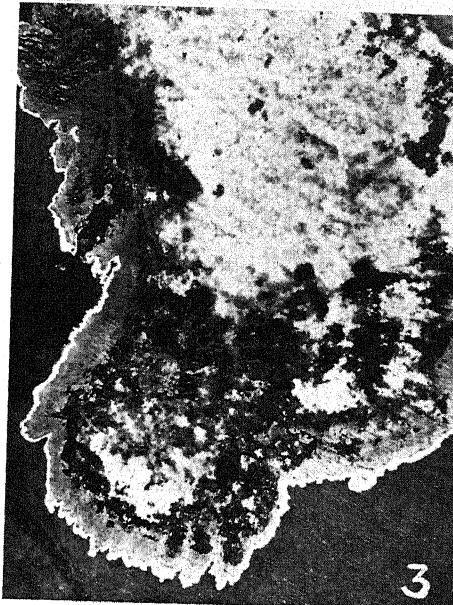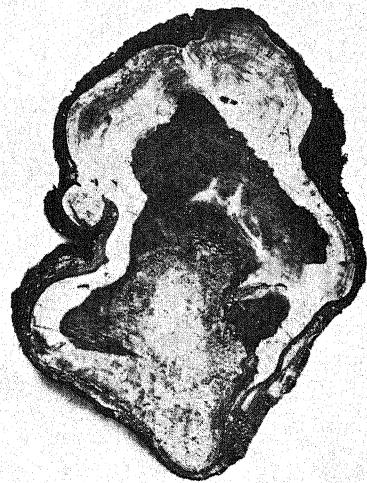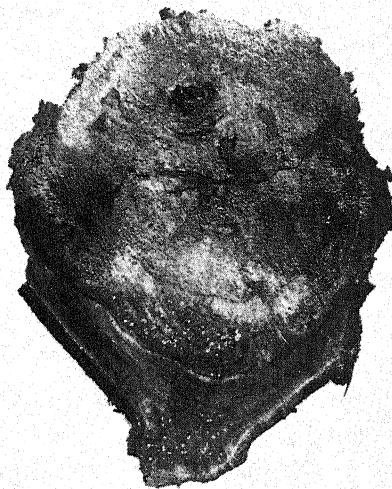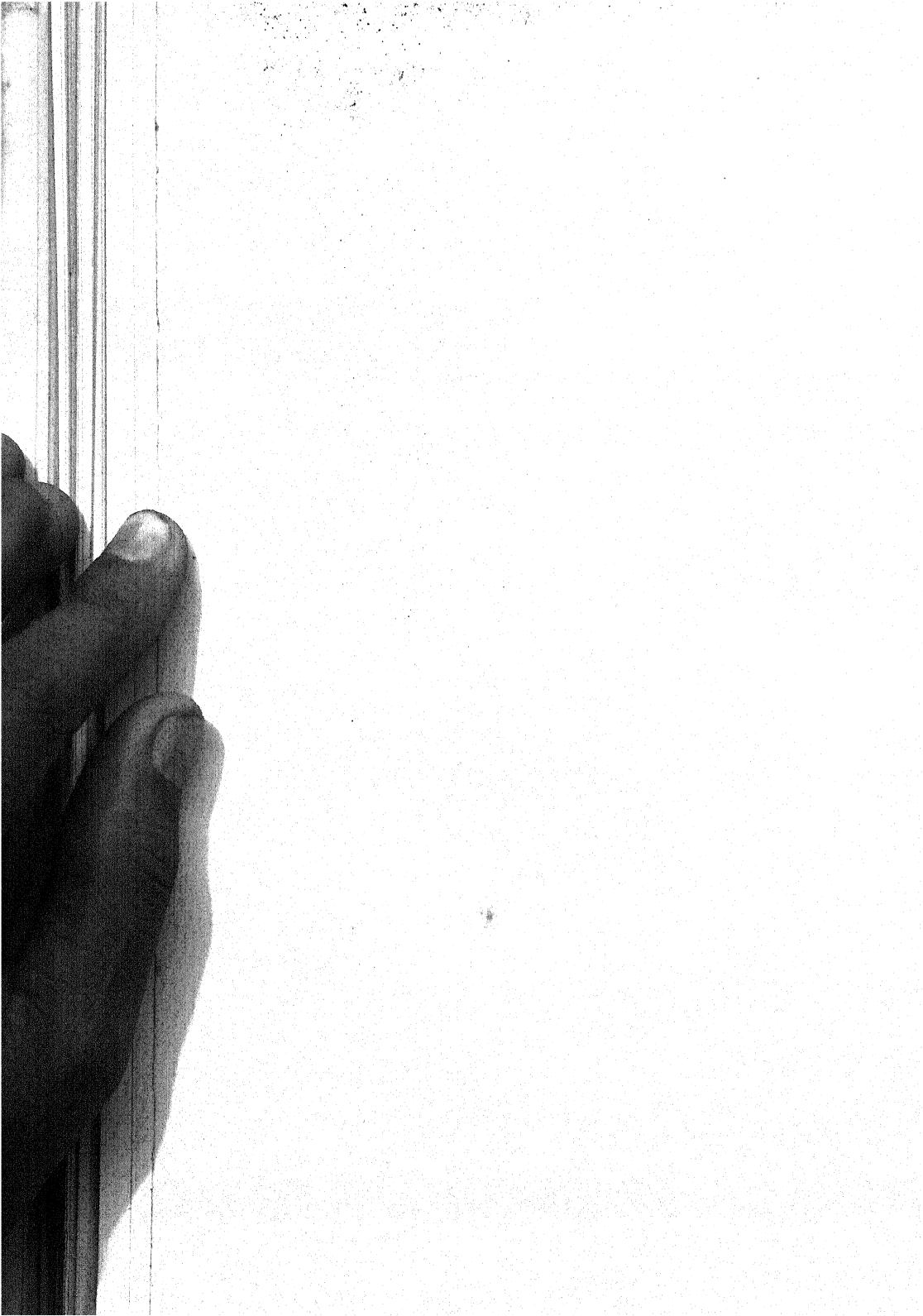
HYGROPHORUS WITH DIMORPHOUS BASIDIOSPORES

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(With 8 Text-figures)

I HAVE found in Malaya two species of *Hygrophorus* with dimorphous basidiospores. Side by side, on the same fruit body, occur large spores on large basidia and small spores on small basidia. The large spores have dense contents and roughly twice the linear measure of the small spores which are hyaline and vacuolate and often with a slightly different shape. The meaning of this dimorphism, which is unknown in any other Basidiomycete, cannot be as great as one would at first suspect and is by no means equivalent to true cryptogamic heterospory. For, in the first place, both species are very similar in all other respects to certain common and well-known European members of this large, unspecialised genus, and unlikely, therefore, to have evolved a new physiological condition. And, in the second place, both kinds of spore invariably occur on the same fruit body, on adjacent hyphae, and all the basidia are tetrasporous and clamped (the small basidia rarely being disporous), so that a sexual or karyokinetic difference can scarcely exist. It is perhaps just the full consequence of a vegetative dimorphism which occurs among the hyphae of the fruit body of these, as in many other agarics: in the primordium, all the hyphae are similar, but some inflate strongly and some hardly at all, and so of the basidial branches, which are initially similar, some inflate strongly to produce the large spores and others but little to produce the small spores. But I have examined only the morphological aspect.

One species, *Hygrophorus firmus*, is known already from Ceylon, where Petch remarked on the dimorphism (4). In Malaya, it varies exceedingly in shape, colour, size and spore characters, surpassing even *Laccaria laccata* or *Omphalia umbellifera*, and, reckoned with its varieties, it is one of our commonest toadstools. The other, which I propose to call *Hygrophorus hypohaemactus* from the rich colour of the hypodermal tissue, is new and probably rare. They differ chiefly in a way which is not infrequent in the genus. In *H. hypohaemactus* the hyphal ends on the surface of the fruit body have mucilaginous walls and their cells are not inflated, whereas in *H. firmus* they have firm, not diffluent, walls and at least over the pileus they are inflated. There is also less dimorphism in the spores and basidia of *H. hypohae-*

mactus, but in colouring, form and hyphal construction they agree. Macroscopically, *H. firmus* is like *H. miniatus*, and illustrations of that species, or Bresadola's of *H. Marchii (Iconogr. mycol.*, Firenze, VII, 343), would represent the typical state. *H. hypohaemactus* inclines rather to *H. coccineus*.

In the first part of the paper I have described the structure and development of the fruit body, which offers certain points of interest in the origin of the pileus, the marginal growth of the limb and gills, and the expansion mechanism of the fruit body. I have also included a summary of the bionomical observations which I have made in Singapore on the fruit body of *H. firmus* var. *stratiotes*: they will be published in detail at a later date together with illustrations of the development and shape of the fruit body in both species and varieties.

THE STRUCTURE OF THE MATURE FRUIT BODY OF *HYGROPHORUS FIRMUS* VAR. *STRATIOTES*

THE STEM. The hyphae are very compact and chiefly of two kinds: either they are strictly longitudinal with inflated cells, 120–1800 × 10–35 μ, or narrow and more or less interwoven with the cells passively extended, 20–200 × 3–5 μ. Both kinds are clamped and the narrow ones are more frequently branched, the branches arising from any part of the cell, generally from the distal half. The contents of the wide hyphae are clear and vacuolate, though sometimes vitreous at the tapered ends of the cells; those of the narrow hyphae are vacuolate and rather smeary-looking, or they are frequently oily throughout, but initially, in the primordium, all the hyphae are similar and the narrow ones begin to acquire their characteristic appearance when the fruit body is about half-developed.

Many intermediates occur between the two kinds, and the one often gives rise to the other. Generally the cells of a hypha are inflated throughout its length or not inflated, but often a few inflated cells may lie between rows of narrow cells, and even the same cell may be inflated at one end only or in the middle, or occasionally in several places, so appearing nodose.

At the surface of the stem the hyphae are all narrow, 3–8 μ, and scarcely inflated. Some of the hyphal ends project obliquely up to 200 μ as narrow filaments with one or two septa and occasionally branched, but they are scattered and there is no palisade of caulocystidia: the terminal and subterminal cells of the hyphae may be slightly inflated, 25–45 × 5–14 μ, especially near the apex of the stem. The hymenium begins abruptly with only a few small tufts of cystidia and sterile basidia preceding it.

The hyphae bordering the hollow of the stem are mostly narrow and not inflated.

The stem is waxy and brittle, owing to this arrangement of the
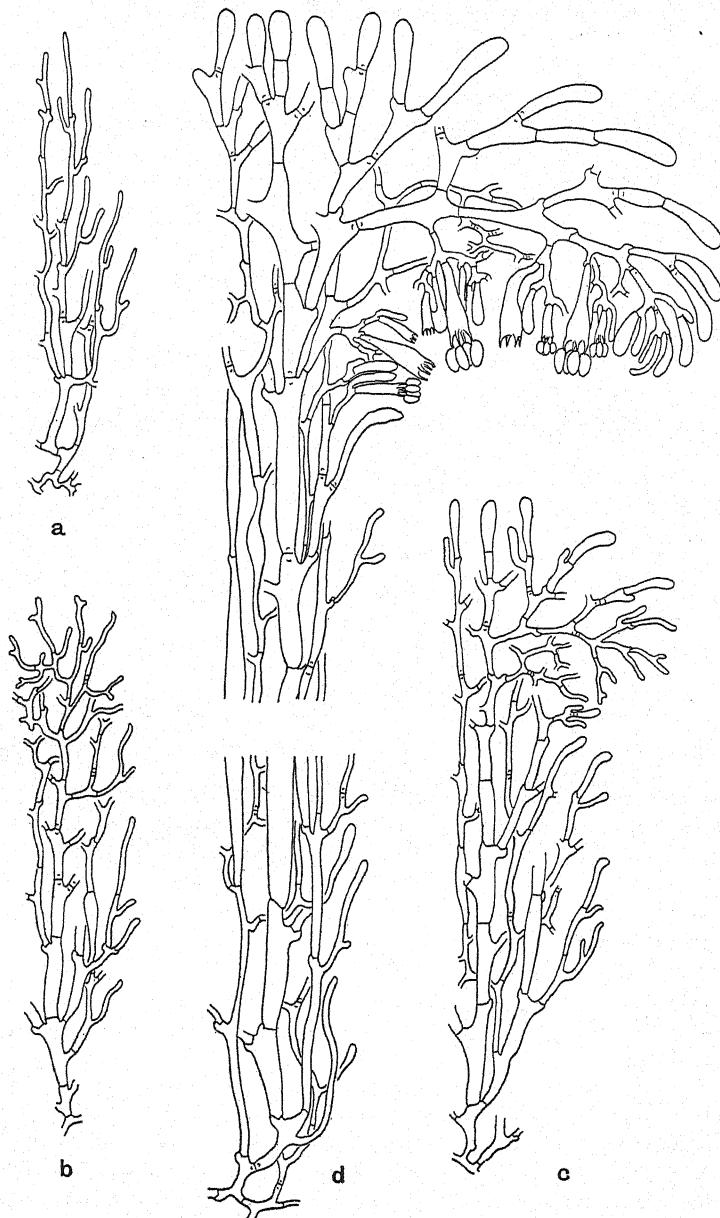
Fig. 1. Diagrams of characteristic hyphae from successive stages in the development of the fruit body of *H. firmus*: *a*, the primordial shaft; *b*, the primordial shaft on development of the pileus; *c*, with primordial limb and incipient hymenium; *d*, the mature fruit body.

hyphae, and snaps easily under the weight of the pileus when displaced from the vertical.

THE PILEUS. The structure is like that of the stem, but the inflated hyphae are frequently 40 μ wide and rarely so long (up to 600 μ). At the surface the hyphae are all inflated. Over the centre their ends form an irregular pile of simple obtuse filaments, two to four cells long, and projecting freely or in groups up to 300 μ high, which gives the scurfy appearance to the disc: their cells are 60–200 × 9–25 μ, and rarely branched. Over the limb the hyphal ends are radiating, adpressed and rather narrower so that the pile is scarcely recognisable and the surface is inoderm, while near the margin their cells are only 20–60 × 7–15 μ and pass conformably into the hymenium.

THE TRAMA. The structure is like that of the pileus, but most of the hyphae are inflated with shorter cells, up to 200 μ long, but as wide as in the pileus. The trama and the tissue of the pileus immediately above the gills are hygrophanous with water, or very dilute mucilage, between the hyphae.

THE SUBHYMENIUM. This tissue is also hygrophanous. It is loosely plectenchymatous, being composed of narrow hyphae with cells 8–35 × 2–4 μ, not inflated, but pulled apart through the intercalary growth of the hymenium.

THE HYMENIUM. The basidia are dimorphic. The large basidia arise deeply in the subhymenium and terminate some distance beyond the general level of the small basidia; the large spores project well beyond the small spores. Both kinds of basidium are borne on the same hyphae, the large basidia being derived from deep-seated laterals and the small basidia from the superficial laterals; intermediates are rare. The small basidia far outnumber the large basidia which are dispersed evenly without bunching, though they are generally absent from the first-formed parts of the hymenium at the junction of the gills with the stem. As the young pileus is expanding, the basidia mature acropetally from the stem apex to the margin of the limb and obliquely outward down the gill to its edge, but very soon the gills become aequihymeniiferous, and large and small spores are shed together. There are no pleurocystidia.

THE GILL EDGE. The construction varies but the edge is always sterile. The simplest condition shows a narrow strip of cheilocystidia, formed from the modified ends of the down-growing tramal hyphae. Transitions between the cheilocystidia and small basidia are frequent, as clavate cells with abortive sterigmata and even rudimentary spores. More complicated conditions show the ends of the tramal hyphae, 3–5 μ wide, far exceeding the hymenium and matted in a loose plectenchyma, while their ends may inflate, 6–10 μ, and appear in surface view as decumbent or immersed cystidia.

THE COLOUR. As is general in *Hygrophorus*, the brilliant red or yellow

(and its modifications in the other varieties of *H. firmus*) is due to a pigment dissolved in the cell sap of the superficial hyphae. The internal hyphae and those of the hymenium are colourless.
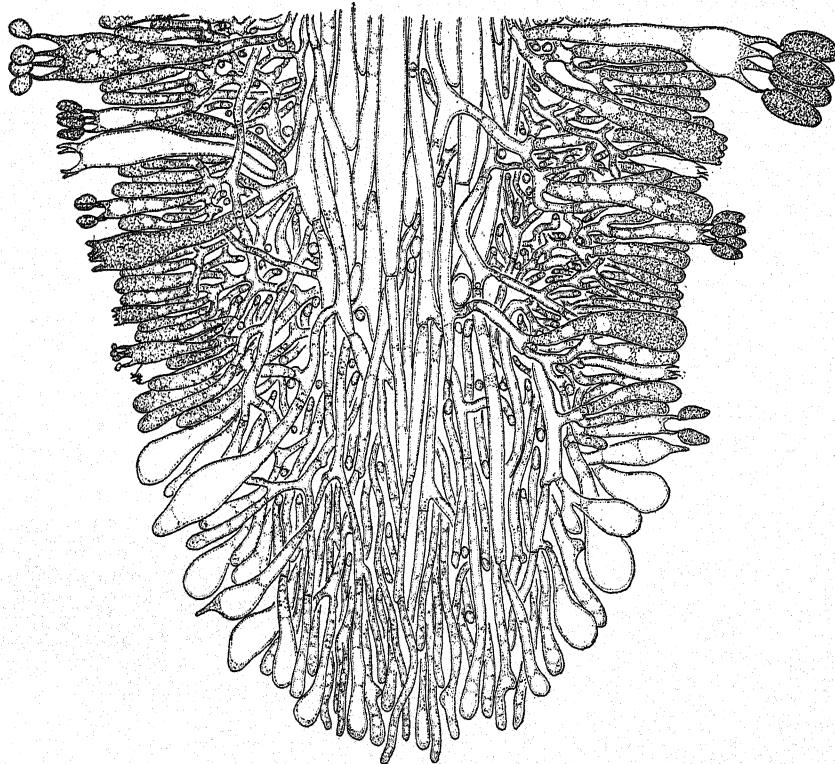
Fig. 2. The edge of a gill of *H. firmus* on cessation of downgrowth; × 400.

THE DEVELOPMENT OF THE FRUIT BODY OF
HYGROPHORUS FIRMUS var. *STRATIOTES*

Macroscopic features. Development is gymnocarpic and direct, with exogenous pileus. A conical primordial shaft, 0·5–3·5 × 1–2 mm., is first developed; it is initially colourless but soon becomes pale orange save at the tip. A small swelling, 1–2·5 mm. wide, then forms at the tip through outgrowth on all sides. Presently the outgrowth increases in an equatorial belt and the limb develops. Through epinasty the limb becomes convex with the margin slightly incurved. All the while, the part below the swelling is enlarging, elongating and raising the pileus, to become the stem; it soon colours scarlet, though not as deeply as the pileus. The primary gills develop almost as soon as

MS   II

the pileus, and the secondaries and higher ranks are intercalated regularly at the margin. The pileus begins to expand before the stem is fully elongated. The limb straightens, becomes horizontal and finally is thrust upward by the expansion of the gills which renders the pileus concave or infundibuliform. The stem soon becomes hollow because the internal tissue is disrupted on expansion of the peripheral, and the excessive growth of the gills may disrupt the central tissue of the pileus and cause the fruit body to be pervious to the base.

Microscopic development

The primordial shaft. Composed of longitudinal interwoven hyphae, the primordial shaft enlarges by apical growth and acropetal inflation of the cells. The hyphal tips, $1\cdot5$–$3\ \mu$ wide (mostly 2–$2\cdot5\ \mu$), are rounded and obtuse with the apical cells 12–$55\ \mu$ long. They grow monopodially and often branch by lobing from the apical cell without concomitant septation, or from the subterminal cells, which are mostly 12–$30\ \mu$ long on delimitation. The direction of growth varies so that the hyphae are interwoven, but as a whole the apex of the primordium grows away from the substratum. The enlargement of the cells begins at the base of the primordium, which is therefore conical; when the primordium is barely $0\cdot5$ mm. high, the hyphae at the base are beginning to inflate, and when $0\cdot5$–1 mm. high, the cells in the basal third measure 20–60×4–$10\ \mu$. The hyphae on the outside of the growing point of the primordium gradually cease growing: they are left behind on the surface and their ends either remain unmodified, adpressed or slightly projecting, or they may inflate slightly, 5–$14\ \mu$ wide, as already described: but they are never abundant and do not branch regularly or profusely so that neither a pile nor a palisade is constructed. The tissue of the primordium is hygrophanous throughout, water filling the interstices between the hyphae and rendering the whole translucent.

This is the general organisation of the primordial shaft in the higher fungi, but it has not previously been described in detail for a gymnocarpic agaric.

The pileus initial. After a short interval, 36–60 hours, from the origin of the primordium, when it is 1–3 mm. long, apical growth is checked. The terminal cells of the longitudinal hyphae at the tip of the primordium begin to inflate, becoming narrowly clavate, 3–$5\ \mu$ wide. From their subterminal cells numerous laterals arise and, growing to the surface by devious routes from various depths, are checked and branch again in their turn. The apex of the primordial shaft thus swells into a small head composed of narrow, $1\cdot5$–$3\ \mu$, densely interwoven hyphae, the ends of which are excrescent from the whole surface except over the original apex of the shaft where a dead space has formed. In this dead space the hyphal ends arrange

themselves in a pile which, together with the underlying interwoven tissue, will become the *disc*, or centre, of the pileus. The dead space extends centrifugally, and simultaneously, the outgrowth from the lower side of the "head" is checked in a zone round the stem apex, and this zone spreads upward over the side of the "head", except along certain radial paths which become the paths of outgrowth of the primary gills. Outgrowth from the head of the primordium is thus checked from above downward and below upward but continues in an equatorial zone as the marginal growing region of the pileus. The form factors begin to play, as usual, in a region where an active and regular outgrowth has been established.

The marginal growth of the pileus. As the hyphal ends grow out in an equatorial zone round the head of the primordial shaft, they build up the limb. This zone becomes the margin of the limb, the growth of which is monopodial like that of the primordial shaft, but the tissue of the limb, which it constructs, is dorsiventral and the margin becomes incurved. This epinasty is due partly to the dorsiventral structure and partly to a directive growth of the hyphal tips. One can consider the limb as a corticated, multifilamentous, centrifugal and fan-shaped soma, the cortex on the upper side being the sterile pile, that on the lower side being the hymenium, and the wide intervening medulla forming the flesh. The hyphal ends in the marginal growing region behave like those at the apex of the primordial shaft, but those which drop behind are modified according as they lie on the upper, outer or lower, inner side (Fig. 3). If they lie to the outside, their terminal cells enlarge, becoming clavate, and eventually inflated up to 25 μ wide: they become coloured, and branch sparingly from the coloured subterminal cells, and form the pile on the pileus: their proximal parts contribute to the medulla of the limb along with the subterminal cells of the main longitudinal hyphae from the margin. If they lie to the inside, their terminal cells enlarge into basidia and are unpigmented. The terminal cells of the upper sterile cortex enlarge sooner and to a greater extent than the first formed basidia in the hymenium (which are undergoing meiosis), and thus the margin of the limb is pressed down and in, toward the stem, as a mechanical effect of the growth of the pile. But the hyphal tips at the margin tend to grow toward the stem by a curvature independent of tissue pressures and determined by some intrinsic property of the apical cells (Fig. 3). There is no evidence that the hyphal tips are geotropic, although they may be negatively phototropic.

The pileus. As already explained, a close pile is built up over the centre of the pileus from the ends of the longitudinal hyphae of the primordial shaft and their laterals. A similar pile is built over the limb, but as the limb extends, the hyphae of the pile do not inflate or branch as much, but are more or less decumbent. The hyphae
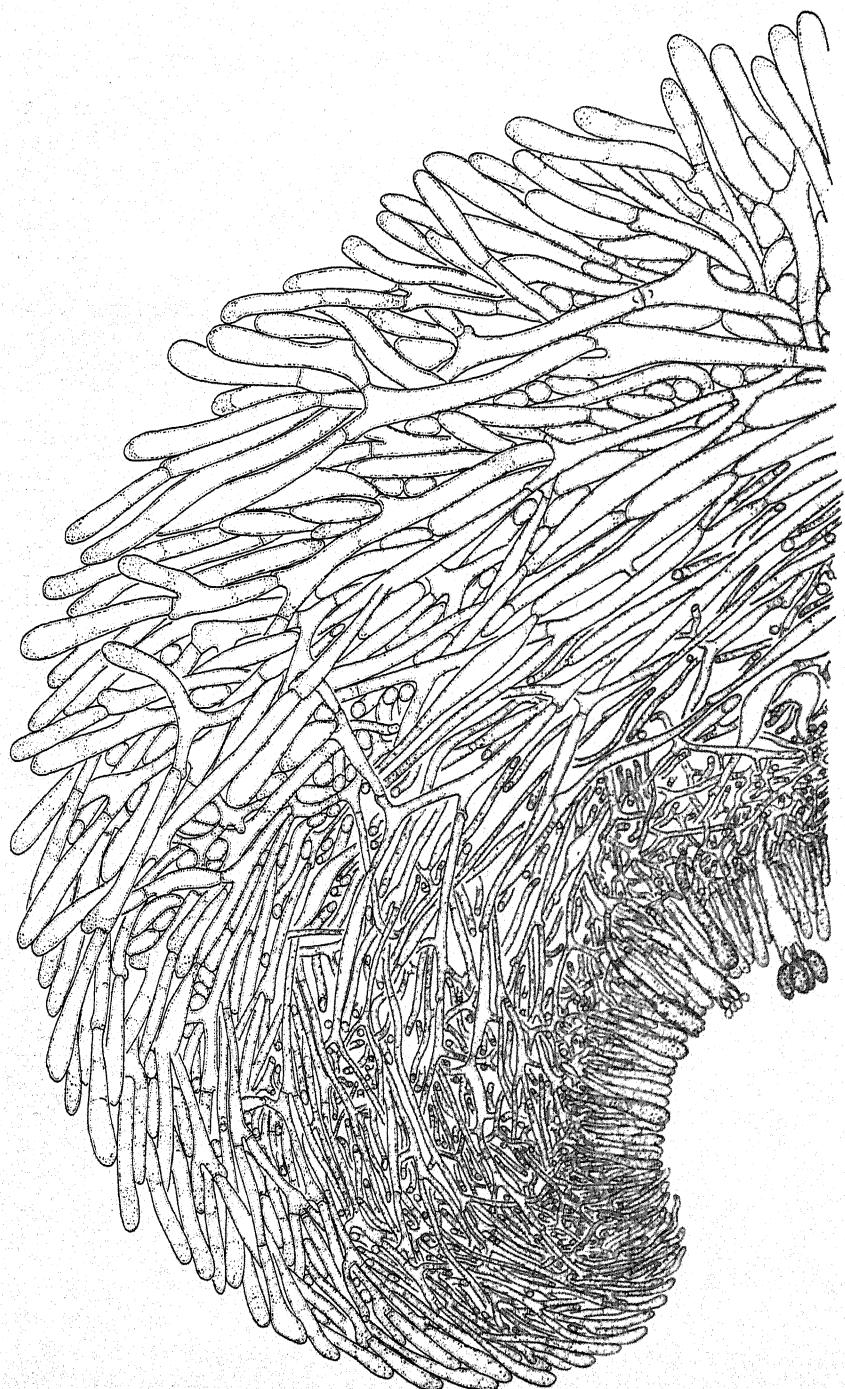
Fig. 3. A radial section of the margin of the limb in the primordial pileus of *H. firmus*; × 250.

of the pile are deeply pigmented and the unexpanded or partly expanded pileus appears like scarlet velvet. As the medulla extends the pile is disrupted into scurfy particles, becoming almost unrecognisable in mature pilei, and the colour is diluted and gradually fades. In some specimens the decumbent hyphae on the upper side of the limb scarcely branch at all and the limb appears inoderm without a pile.

The gills. As in *Collybia apalosarca*(2), the gills develop as ridges along radial paths on the under side of the limb where the outgrowth from the primordial head is not checked. Along these paths, which extend radially with the growth of the limb, the hyphae grow monopodially, as they do at the margin of the limb. The gills are thus formed by the outgrowth of hyphae. This is clear when the tramal hyphae are excrescent to form a loose plectenchyma along the gill edge (Fig. 2). And as the primary gills diverge centrifugally, keeping a constant width, so the secondaries and, in their turn, the higher ranks are intercalated. At the sides of the gill edges the apical growth of the hyphae slows down; their apices bulge out unilaterally at right angles to the tramal hyphae and develop into basidia. The first basidium is generally large. Laterals arise from the subterminal cells and, growing up in the same direction, generally terminate in large basidia: laterals arise from their subterminal cells, and growing up to the level of the large basidia cut off one or two short, subhymenial cells and terminate in small basidia. Sympodial branching then continues profusely, the deep-seated laterals generally becoming large basidia, the more superficial ones small basidia. Thus the level of the hymenium is built out into the gill spaces on a relatively thick subhymenium, and one finds the large basidia scattered among the crowds of small basidia. The large basidia originate in the same way as the pleurocystidia of *C. apalosarca*, and their stalks traverse the subhymenium. On cessation of growth the hyphal ends along the gill edge enlarge into the cheilocystidia.

The basidia and spores. On account of their size the large basidia are convenient objects for study (Fig. 4). One can distinguish three main processes: the accumulation of cytoplasm in the basidium, the vacuolation of the basidium driving the cytoplasm into the sterigmata and spores, and, concurrently, the stretching and stiffening of the cell wall fixes the shape. The basidium is full sized before the sterigmata develop, and the sterigmata before the spores appear; the maximum of the grand period comes toward the end of the first stage at the apex of the basidium with a secondary maximum in the spores.

The basidia enlarge through the accumulation of cytoplasm. While they are slender hyphal ends, they are finely vacuolate and transparent but, as they grow, numerous anabolites are precipitated as reserve substances to be lodged in the spores, and when they are full-sized
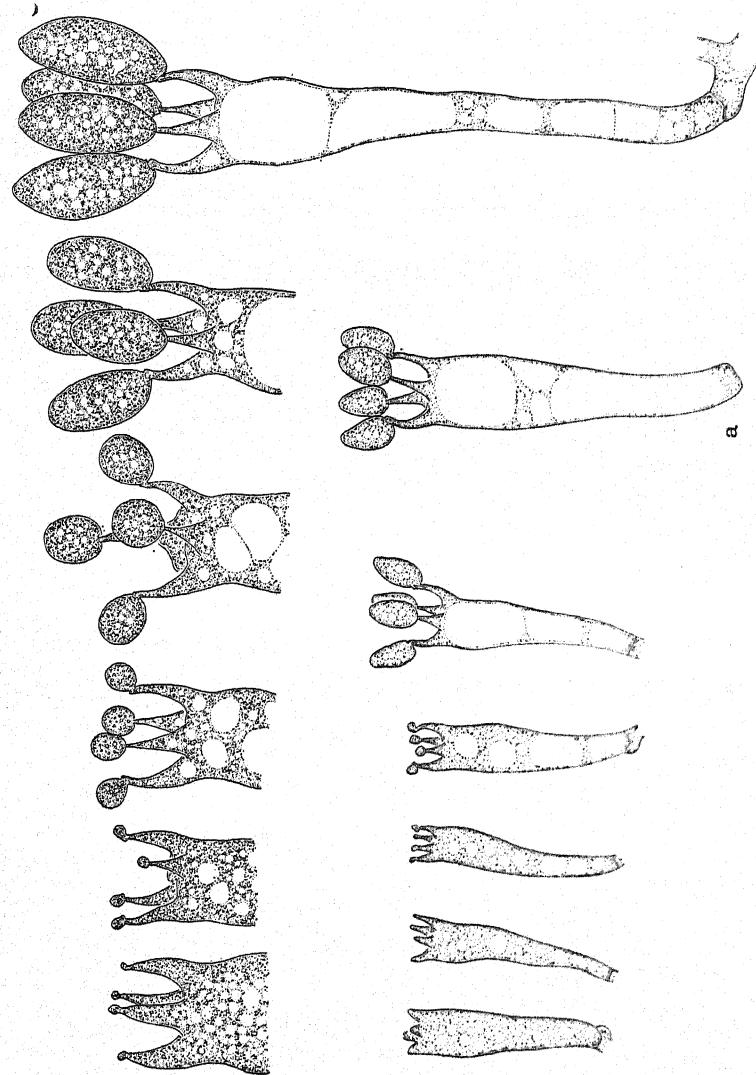
Fig. 4. Stages in the development of large and small basidia of *H. firmus* var. *stratiotes*; *a*, an intermediate basidium; × 1000.

and cut off by a septum their contents throughout are densely granular and guttate. The wall of the basidium stiffens acropetally leaving four thin spots at the apex, and this leads to the second stage. Vacuoles appear at the base of the basidium as a few small spaces in the cytoplasm, then in the middle of the basidium, and as they enlarge they press upon the denser cytoplasm, the pressure being transmitted to the four weak spots at the apex, and the sterigmata are pushed out as *blunt* processes: the internal pressure of the basidium now becomes a simple turgor pressure. The walls of the sterigmata are at first elastic throughout but soon begin to stiffen acropetally and the sterigmata taper to an acute apex: this begins the third stage. The spores arise as minute lateral swellings on the abaxial side of the sterigmata just below their tips, at a point where the wall has not yet stiffened. The vacuoles in the basidium continue to enlarge, forcing the granular cytoplasm into the spore rudiments which swell into spherical bodies, indicating that the spore wall is growing uniformly. The spore wall then begins to stiffen acropetally and the distal end of the spore is forced into a blunt cone, like the sterigma. The basidium and its appendages can then enlarge no further although the turgor pressure continues to rise. This instability leads to the discharge of the spores, which has been fully investigated by Buller(1). The cell wall, in a state of increasing tension, finally gives way at the weakest point, at the necks of the sterigmata, and the basidiospores are violently shot off with a drop of escaped fluid.

How the cytoplasm is forced into the spores can readily be gathered from Fig. 4. The vacuoles must be special structures, for there is no general hydration of the cell contents and their walls must be strong enough to press upon the non-vacuolated cytoplasm. The shapes of the basidium, sterigmata and spores are clearly determined by the properties of the cell wall, especially the extent to which it can be stretched locally. Those parts of the wall where the sterigmata and spores emerge, as well as that which finally gives way, may of course be weakened after stiffening, but it is simpler to construe them as direct steps in the continuous development of the organ: the problem is why the sterigmata and spores are blown out only in certain places.

It is not obvious how the spores are discharged successively, as Buller describes. One would expect the contents of the basidium to escape through the hole in the sterigma as soon as the first spore was shot off; either the hole is too minute or it contracts elastically.

The small basidia and their appendages develop in a similar way; their contents are never coarsely granular or guttulate. The intermediate basidia, which are scarce, develop at intermediate depths in the subhymenium and bear spores of intermediate size. I have never seen small and large spores on the same basidium.

The motor mechanism of the fruit body

One must distinguish between the chief motor mechanism which expands the fruit body and the expansion of the palisades which merely sets up local tissue pressures. The chief motor mechanism lies in the medullary hyphae which gradually inflate acropetally in a grand period of growth in the stem, pileus, and trama, as I have described in *Collybia apalosarca*. Inflation in the primordium is inconsiderable until the pileus is initiated: the medullary hyphae of the stem then rapidly inflate carrying up the rudimentary pileus, the central medullary tissue of which also begins slowly to inflate. The wave of inflation passes from the stem into the pileus, radially to its margin and obliquely outward and downward in the trama of the gills: the stem is nearly fully expanded when the pileus is about half-expanded. The cells in the primordial shaft average $20-2 \cdot 5\ \mu$ on delimitation; they straightway begin to inflate slowly and in the mature stem they average $400 \times 20\ \mu$, elongating about twenty times; this proportion corresponds with the macroscopic growth of the stem: the primordial shaft reaches an average height of 2 mm. and the stem of the full-grown fruit body averages 5 cm.

Not all the medullary hyphae inflate. Very few inflate in the core of the primordial shaft, which is thus disrupted to form the hollow of the stem. The inflating hyphae are dispersed evenly through the medulla of the pileus and trama, which do not become hollow.

The inflation of the palisade hyphae does not take place in such uniform sequence. It is generally basipetal, beginning in the apical cell, soon after it has dropped behind the growing margin, and extending through two to four subterminal cells. The terminal cells of the scattered cortical filaments on the stem, the cells of the pile on the pileus, and the basidia all begin to inflate before their corresponding medullary hyphae, and are often nearly fully inflated before any appreciable internal enlargement has occurred.

Whereas the development of the stem is really indirect (a period of apical growth as a primordial shaft being followed by a distinct period of inflation), the limb and gills develop directly, inflation of the cells following closely on delimitation. The limb is at first convex with slightly incurved margin because, as already explained, the hyphae of the pile inflate more rapidly and to a greater extent than the hymenial hyphae. The limb then straightens centrifugally through the inflation of its medullary hyphae and, finally, owing to the intercalary growth of the hymenium and inflation of the gills, it may be thrust upward, becoming concave and the pileus more or less infundibuliform. The pileus mechanism is similar to, but the inverse of, the apothecial mechanism (3).

THE FRUIT BODY OF *HYGROPHORUS HYPOHAEMACTUS*

Apart from slight differences in the spores, basidia and cystidia, the fruit body of *H. hypohaemactus* is very like that of *H. firmus*: it is gymnocarpic with exogenous pileus, has both inflated and uninflated medullary hyphae, a distinct pile at least over the centre of the pileus, no pile or palisade on the stem, a sterile gill edge, and the pigment in the cell sap. It differs as follows:

Fig. 5. Part of a longitudinal section of the gill of *H. hypohaemactus*, showing the "pseudocystidia"; × 500.

(1) The hyphae of the pile do not inflate, being 2–7 μ wide in mature fruit bodies, but their walls become very mucilaginous. They are sparingly branched, clamped and with simple ends, and are more or less perpendicular to the surface over the disc and decumbent over the limb. The thick grey mucilage, derived from their walls, becomes so copious in wet weather that it swells beyond the limits of the pileus in dentate and appendicular processes.

(2) The superficial hyphae of the stem also become mucilaginous and are not inflated (2–5 μ wide).

(3) The subhymenial hyphae have thin mucilaginous walls and

are not inflated (2–5 μ wide), so that the subhymenium is subgelatinous and rather thick (*ca.* 50 μ at the base of the gills, 10–20 μ near the edge of the gills, and *ca.* 40 μ on the sides).

(4) Some of the laterals of the tramal hyphae do not contribute to the hymenium with clusters of basidia but lie obliquely disposed as elongate fusiform cells with densely granular oleaginous contents and simple, rarely furcate, obtuse ends. They are either wholly embedded, passing from the trama to the subhymenium, or they project up to 50 μ beyond the hymenium into the gill space or from the edge. They are straight or sinuous, simple or once or twice branched, aseptate, thin-walled, 50–600 × 4–16 μ, × 3–6 μ at the apex, and they look like tramal cystidia. The shorter ones may arise from the subhymenial hyphae and appear as true cystidia in the hymenium. In some fruit bodies they are much more abundant than in others, and owing to their varied origin and disposition they can hardly be called pleurocystidia.

The size of the fruit body

The fruit body varies greatly in size in the varieties of *H. firmus*, from 5 mm. to 17 cm. high, and, as I have shown in connection with *Collybia apalosarca*, the problem is to determine whether this variation is due to differences in the amount of inflation or of apical growth of the hyphae. As in *C. apalosarca*, I have analysed a sufficient number of fruit bodies to show, I think, that it is mainly due to differences in apical growth, since the average amount of inflation is roughly the same. Error is, of course, possible in this method of averaging and extrapolating. Only a few cells are measured in the middle section of the stem, midway between apex and base, and these are assumed to indicate the degree of inflation of the whole fruit body. Fortunately the number of gill ranks gives an independent and simple check on the state of the pileus; this indicates that the pilei of those varieties with small fruit bodies are juvenescent. Also, in the same fruit body, the cells vary greatly in their degree of inflation, and owing to the practical difficulty of tracing the longer cells, the shorter are liable to be picked for measurement. To avoid choosing, I seize upon the septa, measuring the cell on each side of it and then pass to the next obvious septum and so on, finally taking the average of fifty. Nevertheless, the results from both *Hygrophorus firmus* and *H. hypohaemactus* are consistent enough to prove that one is not far from the truth. The fruit bodies of varieties *sericeus, minimus* and *gracillimus* may be taken as juvenescent compared with the typical fruit body of *H. firmus* var. *militaris*, and likewise those of *H. hypohaemactus*, but those of the varieties *longipes* and *pachyphyllus* are clearly overgrowths (the average length of an inflated cell from the stem is 400 μ). But the variations in size between fruit bodies of the same

troop, *i.e.* contemporary from the same mycelium, are as often due to differences in apical growth as inflation.

Table A. *Showing the relation between the size of stem and inflation of the cells in* H. firmus

	Stem size in mm.		Stem-length ratios	Average cell length from middle section of stem	Ratios of average cell lengths	Cell extremes	
	Length	Width in middle					
H. *firmus* var. *militaris*	53	2·5	1	460	1	92–1513	One tuft
	50	2·5	0·94	429	0·9	150–825	
H. *firmus* var. *stratiotes*	86	4	1·6	563	1·2	170–1170	One tuft
	75	5	1·4	584	1·3	200–1750	
H. *firmus* var. *gracillimus*	17	1	0·3	398	0·9	150–750	One tuft
	15	1	0·3	374	0·8	120–720	
	11	1	0·2	410	0·9	100–850	
	12	1	0·2	325	0·7	120–600	
H. *firmus* var. *stenophyllus*	40	5	0·75	453	1	150–900	One tuft
	30	4·5	0·6	417	0·9	150–750	
H. *firmus* var. *longipes*	130	5	2·5	407	0·9	150–800	One tuft
	155	7	2·9	470	1	120–1340	
H. *hypohaemactus*	37	3	0·7	430	0·9	100–1000	One tuft
	35	3	0·7	515	1·1	100–1300	
	25	2·5	0·5	435	0·9	100–1050	
	20	2	0·4	400	0·9	175–850	

The gill arrangement

Since the gills subsequent to the primaries are regularly inter-calated at the margin of the limb as the pre-existing gills diverge and before the inflation of the medulla, the number of gill ranks roughly measures the extent of marginal growth; other things being equal, the greater the extent of marginal growth the more the gill ranks, while the amount of inflation is secondary and immaterial to the origin of the gills. Analysis of the gill arrangement provides a con-venient check on the direct analysis of the size of the fruit body. The data obtained from about eighty fruit bodies are enumerated in Table B.

The table shows two facts. Firstly, in those varieties with small fruit bodies, namely *sericeus*, *minimus* and *gracillimus*, the small size of the pileus is due to the lesser growth of the limb. This is the explanation deduced in the previous section for the shortness of the stem in var. *gracillimus*, and one is therefore justified in considering the fruit bodies of these varieties as juvenescent. Secondly, the varia-tion in size of the fruit bodies growing in the same tuft is due partly to a lesser extent of apical growth and partly to the lesser inflation. When many primordia develop close together from the same my-

Table B. *Showing the relation between the gill arrangement and size of fruit body in* H. firmus

	Number of		Diameter in mm.		
	Primaries	Ranks	Pileus	Stem apex	
H. firmus var. *militaris*	30	2	42	12	One tuft
	31	2	37	10·5	
	29	2	33	9	
	32	1–2	29	6	
	30	2	27	9·5	
	32	2	27	7	
	30	2	22	5	
	30	1–2	19	5	
	29	1–2	18	5	
	31	1–2	15	5·5	
H. firmus var. *stratiotes*	25	2–3	30	8	One tuft
	21	2–3	30	7	
	19	2–3	28	7	
	15	2	18	2	One tuft
	12	1–2	14	1·5	
	11	1–2	12	1	
	36	3–4	40	11	One tuft
	35	3–4	40	11	
	34	3	39	9	
	33	3–4	38	9	
	32	3	36	7·5	
	33	2–3	25	4	
	35	2–3	18	3·5	
	34	2–3	12	2	
	28	2–3	20	4·5	One tuft
	25	2–3	20	4·5	
	23	2–3	20	4	
	28	2	14	3·5	
	24	2	14	3·5	
	34	3–4	31	5	Miscellaneous
	24	3–4	35	5·5	
	24	3–4	27	5·5	
	23	2–3	23	5	
	23	3–4	18	3·5	
	23	3	18	3·5	
H. firmus var. *flavus*	23	2	18	2	One tuft
	20	1–2	16	1·5	
	18	1–2	14	1·5	
H. firmus var. *flavo-albus*	25	3	25	6	One tuft
	21	2–3	20	4·5	
	19	2	18	4	
H. firmus var. *stenophyllus*	39	3	30	7	One tuft
	36	2–3	29	6·5	
	35	2–3	28	6	
	37	2	27	6	
H. firmus var. *longipes*	31	3	45	7	One tuft
	30	2–3	44	7	
	33	3	40	6·5	
	32	2–3	32	5·5	
	34	2–3	31	4·5	
	29	2	25	4	
H. firmus var. *sericeus*	12	1–2	10	1	One tuft
	12	1–2	9	1·5	
	13	1–2	7	1	
	13	1	6	1·5	
	14	1	5	1	
	12–18	1–2	5–12	1·5–2	
H. firmus var. *minimus*	7–10	1	4–10	0·5–1	One tuft
H. firmus var. *gracillimus*	10–12	1 (–2)	4–7	1	One tuft

celium, they grow equally for a short time, then some take the lead, developing normally, and the rest are more or less stunted: in fact, in caespitose species one can generally find in the mature tufts all transitions from fully developed fruit bodies to rudimentary and distorted primordia, and care must be taken not to include these abortive fruit bodies in material for developmental studies. Sometimes the stunted primordia have undergone their full amount of apical growth, for they possess the full complement of primaries and
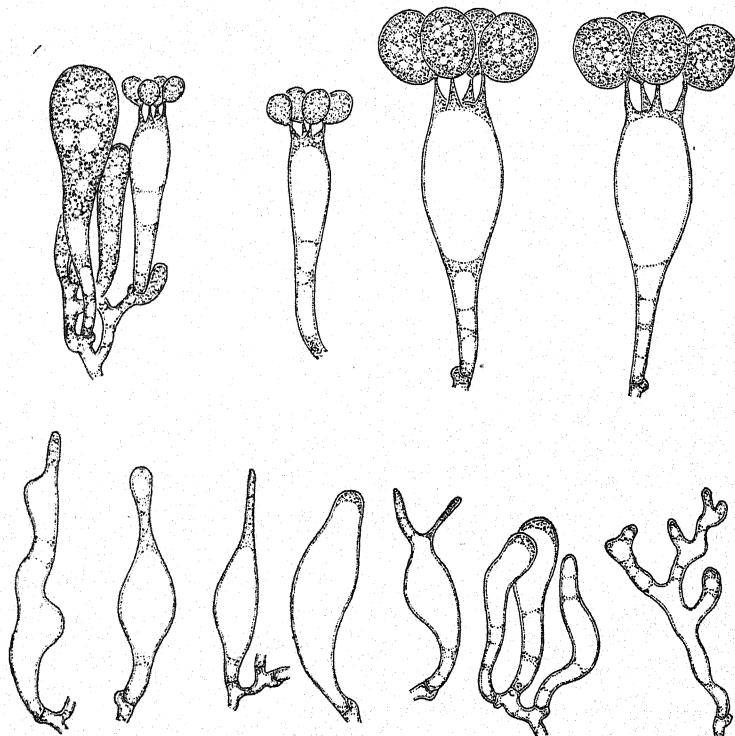
Fig. 6. Large and small basidia and cheilocystidia of *H. hypohaemactus*; × 1000.

gill ranks, but they are stunted through lack of water for inflation. Apical growth of other primordia may be checked prematurely and these develop into fruit bodies which are not merely small but which have fewer primaries and gill ranks. The mycelium lays down more initials than it can mature; their demands exceed the supply of food and water, and but a few develop normally. It is not until one begins to watch the primordia in the field that one realises how many failures there are. I have never seen an aborted primordial shaft expanded into a *Clavaria*-like body; unless the pileus is developed to an appreciable extent, the primordium aborts completely.

Discussion on development

Some American investigators have contended that the gills of agarics arise through the buckling of the hymenium as it undergoes intercalary growth and not by an active outgrowth along certain paths (2). They state that the hymenium of the primordium is at first flat and, as the basidia inflate and as more are intercalated sympodially, so the hymenium is compressed between the incurved margin of the limb and the stem apex: a tension develops which is relieved by throwing the hymenium into radial folds. That this explanation rests on misunderstanding is evident from the following considerations:

(1) It is not obvious that such a state of tension would be relieved by simple radial buckling. Considering the intricate connections of the hymenium it would most probably be thrown into anastomosing wrinkles, defining more or less hexagonal areas, *e.g.* the species of *Cantharellus*, *Craterellus*, *Cyphella*, *Marasmius*, *Campanella* and *Stereum* with wrinkled hymenium.

(2) Why should not such a lateral pressure cause merely a hyponastic curvature of the limb, which is free to move in either direction? Actually the tension in the primordial hymenium, when the gills are developing, is never enough to overcome that of the pile on the pileus which forces the limb towards the stem.

(3) If the gill ridges buckle out from the limb, why are there not schizogenous cavities overlaying the gills, like the hollow in the stem?

(4) Why are gill ridges not developed on the upper side of the pileus in species with a compact pile or palisade, *e.g.* species of *Boletus*, *Pluteus*, *Mycena*, *Marasmius*, *Psathyra*, *Coprinus*, etc.? Such a palisade of contiguous inflated cells, increasing their numbers by sympodial branching, presents exactly the same problem as the primordial hymenium. At most, anastomosing wrinkles develop, as in *Pluteus phlebophorus*, *Lactarius fuliginosus* and *Psathyra corrugis*.

(5) How can the secondaries and higher ranks be intercalated regularly by this means? When as rarely happens anastomosing wrinkles are developed, they offer no such order.

(6) How would the tramal hyphae stand the stretching? For the cells of some might be pulled out for several millimetres, and if they broke that part of the hymenium supplied by them would perish.

(7) Why should the tramal hyphae be so compactly arranged and strictly longitudinal in the typical gill?

I think that it will always be found that the gill ridges are lines of outgrowth as I have described in *Collybia apalosarca* and *Hygrophorus firmus*. But how they are blocked out at the margin of the limb by sectors of inhibition is a profound problem. The morphologist always comes against such barriers which limit his researches and show where he must hand over to the experimenter.

The biology of the fruit body

The fruiting of *Hygrophorus firmus* in Malaya is seasonal. It takes place during a week or two in each wet season after a dry spell, which must be of two or three weeks duration and pronounced enough to dry off the surface layer of humus in the forest. In Singapore such a spell generally occurs twice a year, in February and in July or August, and it is followed by a period of three to four months' intermittent rain during which the humus is always moist. The fruit bodies of *H. firmus* then begin to develop some six weeks after the break in the dry weather. Over a small area of forest where the rainfall is uniform, one may therefore find the troops of fruit bodies twice a year during one or two weeks, and only very sporadically, if at all, in the intervals. Each mycelium fruits once only in each season.

I have watched to completion the growth of forty-three fruit bodies of *H. firmus stratiotes*, and many others which were less complete.
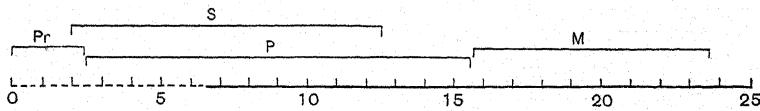
Fig. 7. A diagram of the life of a fruit body of *H. firmus* var. *stratiotes*: the continuous basal line covers the period of sporing: the figures are days (24 hours): *Pr*, the primordial shaft; *S*, stem elongation; *P*, pileus-enlargement; *M*, maturity.

Development is gradual. The total life of the fruit body varies from twenty to twenty-seven days, being generally twenty-three to twenty-four days. The apical growth of the primordial shaft occupies the first two or three days. The stem elongates during the next seven to twelve days; the pileus continues to expand for a further three to five days and the fruit bodies persist full-sized and mature for a final period of four to ten days. Sporing begins when the pileus is 4–6 mm. wide, that is to say on the sixth to seventh day. These facts are delineated for an average fruit body in Fig. 7. It is not, of course, easy to judge either when the primordium is initiated, because it is hidden in the soil, or when the fruit body is thoroughly effete, because the limb collapses gradually: a day or so may therefore be added or subtracted both from the beginning and the end of this scheme. But, certainly, the primordial shaft grows remarkably quickly. The stem elongates most rapidly during the interval from the seventh to tenth day, the pileus from the ninth to thirteenth day. The stem often begins to rot at the base before the limb collapses, especially if there is much rain, and this may cause the premature death of the fruit body.

The fruiting of *H. hypohaemactus* also appears to be seasonal, but

owing to its scarcity I cannot state this categorically. During the four years, 1929–32, it has fruited twice a year in the Singapore Botanic Gardens at intervals of two to four months after the break of the dry spell. It certainly develops much later in the wet season than *H. firmus*. General observations show clearly that the fruit bodies have a similar slow growth and long period of maturity, although I have not been able to study them in detail. This slow development and indefinite period of sporing is probably characteristic of the more massive gymnocarpic agarics such as *Hygrophorus*, *Clitocybe*, *Entoloma*, etc., and it is in striking contrast with the rapid evolution and precise mechanism of *Collybia apalosarca* and the angiocarpic genera *Amanita* or *Coprinus*.

SYSTEMATIC SECTION

Hygrophorus firmus B. & Br. (= *H. firmus* var. *typicus*).

Pileus 1–4 cm., at first convex, becoming plane and slightly umbilicate, sometimes infundibuliform or pervious to the base of the stem, *minutely scurfy squamulose over the disc*, innately fibrillose and striate toward the margin, *dry, orange-red or scarlet*, paler on expansion and pale yellowish when old; margin slightly incurved at first, often crenatoplicate.

Stem 3–8 cm. × 2–12 mm., equal, slightly thickened above or attenuate downward, dry, smooth, *becoming hollow*, rather stiff, often flattened below, *paler concolorous*, discolouring pale yellowish; base white, abrupt.

Gills shortly decurrent, often more or less broadly sinuate, *distant*, 1–4 ranks, with 16–40 primaries, 2–3·5 mm. broad, rarely forked near the stem, rather thick, not veined or very slightly, *concolorous at first, becoming pale yellow or whitish*, yellowish at the base; trama pallid yellowish.

Flesh thin, 1–2 mm. in the centre, 0·3–0·5 mm. half-way to the margin, watery, rather soft, *concolorous*; smell and taste none.

Spores white, ellipsoid, smooth, thin-walled, *dimorphous: large spores* 12–16 × 7–10 μ, broadly oblong ellipsoid, ends blunt, slightly flattened adaxially, sometimes narrowed distally rather suddenly and waisted, with a prominent lateral-basal apiculus, *with dense granular-oleaginous contents: small spores* 5–8 × 3·5–4·5 μ, more or less pip-shaped, widest in the proximal half, *with hyaline, cloudy vacuolate contents.*

Basidia dimorphous: large basidia 50–75 × 12–16 μ, clavate, with dense granular-oleaginous contents at first, becoming hyaline, with four large sterigmata 8–11 × 3–4 μ at the base: *small basidia* 28–40 × 6–8 μ, subclavate or subcylindric, contents cloudy-vacuolate, with four, rarely two, sterigmata 5–7 × 1·5–2 μ at the base.

Cheilocystidia 25–60 × 7–30 μ, cylindric, clavate or vesicular, rarely ventricose, thin-walled, colourless, vacuolate, sometimes with one to five short cylindric processes up to 5 μ long from the distal end, as abortive sterigmata: forming a narrow sterile edge, often inconspicuous and with all transitions to sterile basidia.

Caulocystidia absent or as a few irregular sterile basidia at the apex of the stem.

Habitat, in troops or small tufts in the lowland and mountain forest up to 4000 ft.; Ceylon, Malaya.

The varieties of *H. firmus* can be arranged in two sections, Ovalisporae and Macrosporae. I have given, in the following descriptions, only the distinctive characters of the varieties which in other respects, unmentioned, may be taken as identical with the typical state.

OVALISPORAE. Sporis magnis 12–16 × 7–10 μ, late ellipsoideis vel ovoideis, apicibus obtusis, vix attenuatis.

var. *militaris* var.nov.

Stipite albo vel primo pallide flavo.

This variety appears commoner than the type, at least in Singapore. Growing in troops, with scarlet cap and stiff white stem, its carriage is soldierly.

var. *puniceoides* var.nov.

Pileo 7–8 cm. lato, magno, convexo-plano, non umbilicato: stipite 6–7·5 cm. × 7–9 mm., claro flavo: lamellis latis, 6–10 mm., adnexis, saepe dentibus parvis decurrentibus praeditis, pallide citrino-flavidis: carne crassa, 3–4 mm. medio pileo, pallide alba: sporis magnis minusculis, oblongis, saepe paulo constrictis, 12–15 × 7–9 μ.

I found this variety once, at Tembeling in Pahang, November 4th, 1930. Macroscopically it is so like *H. puniceus* that one would not consider it related to *H. firmus*, although microscopically it is essentially the same.

MACROSPORAE. Sporis magnis 16–25 × 7–11 μ, longo-ellipsoideis, plus minus fusiformis, saepe paulo curvatis vel allantoideis, apicibus subacutis, distincte attenuatis.

var. *stratiotes* var.nov.

Forma typica persimilis sed sporis majoribus, 18–25 × 7–11 μ.

Macroscopically this variety is indistinguishable from the typical state. The basidia are generally of the same size, though the large ones may reach 18 μ wide. It is the commonest variety in Malaya, and I have found it frequently in Singapore, Johore, Pahang and Negri Sembilan, where it may be expected every season.

var. *pallidipes* var.nov.

Stipite albo.

This variety stands to var. *stratiotes* as var. *militaris* to the typical state. It is not uncommon.

var. *depallens* var.nov.

Pileo albido vel flavido, raro carneo-flavido: stipite 7–10 cm. × 4–6 mm., flavido, apice albo, vel ex integro albo: lamellis latis, 6–7 mm., pallide carneo-ochraceis.

I have found this variety only in the Reservoir Jungle in Singapore. It is poorly pigmented and the pinkish gills suggest *Entoloma* or *Leptonia*.

var. ***sericeus*** var.nov.

Pileo parvo, 5–12 mm., cano-albo, subfibrilloso, sicco atomato: stipite 2–2·5 cm. × 1·5–2 mm., ceraceo, citrino-flavido: lamellis albis dein pallide carneis: sporis magnis 16–21 × 6·5–9 μ: sporis parvis 6–8·5 × 3–3·5 μ.

I have found this variety on the hill, Bukit Timah, in Singapore. Macroscopically it exactly recalls *Leptonia sericella*: the loose, sparingly branched, decumbent hyphae give the limb the silky fibrillose appearance. It differs from var. *depallens* in the smaller size, narrow gills, smaller spores and paler colour.

var. ***flavus*** var.nov.

Stipite et pileo citrino-flavo vel saturatiori: lamellis flavidis, dein albidis: sporis magnis 16–22 × 10–11 μ: sporis parvis 5–7 × 3·5–4·5 μ.

This variety appears every year in the Aroid Rockery in the Singapore Botanic Gardens, where there are many forest trees. The fruit body is brilliant yellow without a trace of red.

var. ***flavo-albus*** var.nov.

Pileo flavido: stipite albo: lamellis albis, latis, 4–6 mm.

This variety is so very close to the preceding that, perhaps, it hardly deserves a name. It is a further step, however, to the following albino condition. I have found it in the Reservoir Jungle, Singapore. Bresadola's illustration of *H. lucorum* (*Iconogr. Mycol.* VII, 314) would pass macroscopically for this variety.

var. ***albus*** var.nov.

Ex integro albus.

I found a troop of fourteen fruit bodies of this variety by the Cheka River in Pahang, on November 12th, 1930. The fruit body is devoid of pigment, though in shape, size, and microscopic characters identical with var. *stratiotes*.

var. ***roseus*** var.nov.

Pileo purpureo-roseo vel carneo: stipite albo vel pallide carneo: lamellis pallide carneis, pallescentibus.

This variety is not uncommon. I have found it in Singapore and at Tembeling and Fraser's Hill (4000 ft.) in Pahang. The fruit bodies are often rather larger than typical, especially in length of stem. It leads both to the following and to var. *longipes*.

var. ***amethystinus*** var.nov.

Pileo purpureo-vinaceo: stipite albido: lamellis claro amethystinis, ut *Laccaria laccata* var. *amethystina*.

I found this most striking variety as a troop of twenty fruit bodies in the forest at Tembeling, Pahang, on November 9th, 1930. The

colour is so unlike that of a *Hygrophorus*, lacking all trace of red and yellow, that it suggested *Tricholoma* or *Clitocybe*. Microscopically it is indistinguishable from var. *stratiotes*.

var. *pachyphyllus* var.nov.

Pileo 5–6 cm. lato: lamellis perlatis, crassis, 8–10·5 mm. latis, ad basim 2 mm. crassis.

I have not analysed the property of thick gills in this variety, but it is doubtless caused both by an excessive marginal growth and inflation or intercalary growth. It occurs not infrequently in the Reservoir Jungle, Singapore.

var. *stenophyllus* var.nov.

Pileo convexo-plano, citrino-flavo: stipite citrino-flavo: lamellis albis, angustis, 2–2·5 mm. latis, subdecurrentibus, late sinuatis vel subarcuatis.

I found a troop of some fifty fruit bodies of this variety on Fraser's Hill, Pahang, May 27th, 1930, at 4000 ft. altitude. Only the largest fruit bodies had spores; those with pilei less than 16–20 mm. wide were not yet fertile. It may be an abnormal form of var. *flavus*, partly sterile and thus with narrow gills.

var. *longipes* var.nov.

Stipite saepe altissimo, 5–17 cm., apice 4–7 mm., basi 5–10 mm., albo: lamellis saepe perdecurrentibus, 3·5–4·5 mm. latis, albis.

The pileus is typical, 2·5–4·5 cm. wide, scarlet fading to orange or pale yellow, and with the full gill complement. The enormous length of stem, as shown in the preceding section, must be due to long-continued apical growth of the primordial shaft, since the average inflation of the cells is typical. Such a state might be evoked through an external factor as weak light, unusual temperature or high humidity, but the fruit bodies may be found in open sunny places by paths in the forest, in deep shade, in humus, or on bare sandy banks, and both in the lowlands and the mountains. I have found it at Padang Piol, near Tembeling, and at Fraser's Hill (4000 ft.) in Pahang. In the collection from Padang Piol and most of those from Fraser's Hill the spores are as in var. *stratiotes*, but in one collection from Fraser's Hill they were unusually large, as shown in Fig. 8 *e*: the large spores measured 22–27 × 9–11 μ and the small spores 9–12 × 4–4·5 μ. Scattered through the forest on Fraser's Hill I have also seen specimens of this variety which were wholly white or with the faintest tinge of yellow on the pileus, but I have no accurate data on them.

var. *minimus* var.nov.

Pileo pusillo, 4–10 mm. lato, convexo-plano, raro subumbonato vel subum-

bilicato: stipite brevissimo, 5–10 × 1 mm., solido: lamellis arcuatis, perdecurrentibus, distantis, 7–10 primis, ordine uno, raro secundo incompleto, instructis.

Apart from their minute size, the fruit bodies of this variety are identical with those of var. *stratiotes*. As shown already, they must be regarded as juvenile forms with limited apical growth and normal turgescence. It is not infrequent, but easily overlooked. I have found it in Singapore, round Gunong Panti in Johore, and at Tembeling in Pahang. Generally the fruit bodies are scattered and few.

var. **gracillimus** var.nov.

Pileo pusillo, 4–7 mm. lato, convexo-plano, subumbonato, plus minus turbinato, flavido vel albido, centro saturatiori carneo-aurantiaco: stipite gracili, 15–25 × 1 mm., solido, translucido, pallide aurantiaco: lamellis subtriangulis, breviter decurrentibus, uno ordine, raro secundo incompleto, instructis, 10–12 primis, 1–1·5 mm. latis: sporis 18–23 × 9–10, et 8–10 × 3·5–4 μ.

This variety differs from the preceding in the longer, slender stem and pale colour. It looks like an *Omphalia*. I have found it only on Fraser's Hill by the path to the waterfall, but in a troop of over a hundred individuals growing in moss on a sandy bank, and in two successive seasons, in May and November, 1930.

Hygrophorus hypohaemactus spec.nov.

Pileus 2–2·7 cm. latus, convexus dein planus, margine primo incurvato, *viscoso-papillosus*, glutine hyalino griseo viscido adnato, in medio pileo 1–1·5 mm. crasso, marginem versus tenuiori, saepe supra marginem in vittas triangulas usque 1 mm. longas projicienti, *obtectus, umido striatus*, sub glutine *rubro-sanguineus, dein pallescens*, demum pallide aurantiacus vel flavidus.

Stipes 3–6 cm. × 2·5–3·5 mm., *cylindricus*, solidus dein cavus, *viscidus*, glutine simili, saepe peronato-disrupto vel crispato, obtectus, *pallide aurantiacus vel rubro-aurantiacus*, demum pallescens.

Lamellae adnatae vel adnexae, separantes, *subdistantes*, crassiusculae, ordinibus 3–4 instructae, primae 18–20, 2·5–3·5 mm. latae, *ceraceo-submucosae*, margine obtuso continuo dein mucoso et interrupto praeditae, *albae, basim versus pallide aurantiacae*.

Caro tenuis, medio pileo 1–1·5 mm. crasso (glutine subtracto), *concolor*: odore deficiens.

Sporae albae, laeves, dimorphae: *sporae magnae* 8–10 × 6·5–8·5 μ ovoideae vel lato-ellipsoideae, intus granuloso-oleaginosae: *sporae parvae* 4–5 × 3–3·5 μ, sub-globosae, basim versus attenuatae, intus nebuloso-vacuolatae, vix vel haud granulosae.

Basidia dimorpha: *b. magna* 33–44 × 10–12 μ, stipitato-ventricosa sterigmatis 4, 5 μ longis, praedita: *b. parva* 20–28 × 5–6 μ, subclavata, sterigmatis 4, 3–3·5 μ longis, praedita.

Cheilocystidia 16–40 × 4–9 μ, polymorpha, subclavata, clavata, ventricosa, saepe flexuosa, hyalina, vacuolata, tenuiter tunicata, apicibus plerumque simplicibus, saepe 1-ramosis vel lobatis vel appendicibus 2 sterigmatoideis praeditis: *pleuro-cystidia* vera absentia.

Hab. ad terram in silvis: Malaya.

I have found this species only in the Garden's jungle and once at Tembeling, in Pahang. It has caulocystidia only at the extreme apex of the stem where they are like the cheilocystidia but rather longer,

up to 60 μ, more flexuous and more branched and irregular, and they form a few compact clusters, as in *H. firmus*, immediately preceding the hymenium.

<div align="center">SYSTEMATIC DISCUSSION</div>

It is not easy to decide in a species so variable as *Hygrophorus firmus* which state shall be reckoned the typical. Very fortunately the collections from Ceylon, whence the species has hitherto been known, are the most generalised and approach nearest to what is supposedly the ancestral state. They are thus qualified on grounds other than mere "type collection" to hold such a position. The same state occurs in Malaya, and with the local material I have amplified Petch's description in the foregoing section as *H. firmus* var. *typicus*. These dimorphous species are surely derived from the section of *Hygrophorus* including *H. miniatus*, *H. Reai*, *H. turundus*, etc., which have fruit bodies of similar shape, colour and manner of development. The spores of this section are typically subglobose, 6–9 × 4–7 μ, with fairly dense, granular or cloudy vitreous contents, and not only do the large spores of *H. firmus* pass through such a stage in their development but those of *H. hypohaemactus* are little removed from it and lead through the Ovalisporae to the Macrosporae (*vide* Fig. 8). The fruit bodies of this section are also of medium size and more or less fully pigmented as in *H. firmus* var. *typicus*. Thus the other states of *H. firmus* may be looked upon simply as variants in size and pigmentation. Regarding these varieties there are the following facts:

(1) In any one troop the fruit bodies, which are presumably derived from the same mycelium, all have the same special characters. I have never seen two varieties mixed in the same troop or even growing in the immediate vicinity of each other.

(2) The same varieties occur in such widely separate localities as Singapore, Johore and Pahang, *e.g. stratiotes, militaris, minimus, pallidipes, roseus* and *longipes*.

(3) Certain varieties I have found repeatedly on the same patch of ground each season so that their mycelia must have constant characters, *e.g. militaris, stratiotes* and *flavus* in the Singapore Botanic Gardens (1929–32), *pallidipes* in the Reservoir Jungle, Singapore (1930–32), and *gracillimus* and *longipes* on Fraser's Hill, Pahang (May, November, 1930).

The characters of the varieties are clearly fixed and hereditary, and it is a problem whether some should not rank as species. Indeed, should not one propose a new genus based on the dimorphous spores, with two subgenera, the one for *H. firmus* with dry pileus and stem and the other for *H. hypohaemactus* with viscid? Yet it is equally clear that many of the varieties are merely colour forms and that intermediates will probably be found. Moreover, anatomical knowledge

of the Hygrophorei is far too meagre to allow the recognition of natural genera. Is it usual in *Hygrophorus* for some only of the hyphae to inflate the fruit body? I would have refrained even from varietal names were they not necessary for accurate description and to emphasise the extraordinary range in size, shape and colour which *H. firmus* displays. And though it is a common species, many years must elapse before we have a full knowledge of it: the period of fruiting is so brief that one traverses the forest without meeting with it many times. The following remarks therefore are only tentative.

The Ovalisporae may differ specifically from the Macrosporae. The spores of *H. firmus* are fusiform-ellipsoid because the stiffening of the distal part of the wall, when the spore is in the subglobose
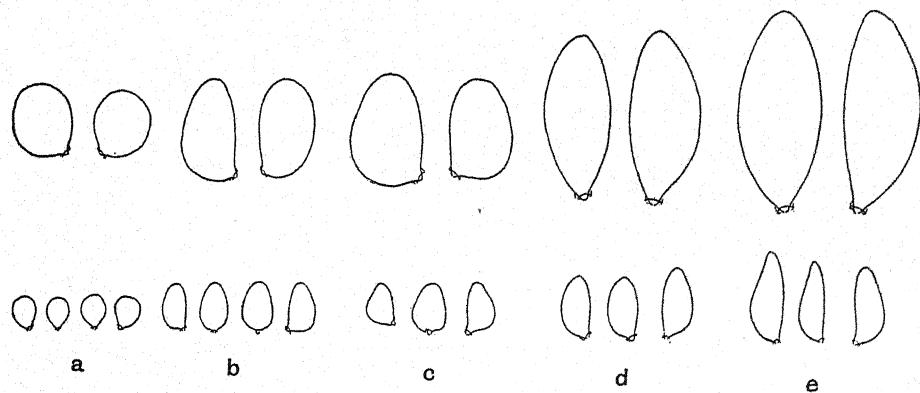
Fig. 8. Large and small spores: *a, H. hypohaemactus*; *b, H. firmus* var. *puniceoides*; *c, H. firmus* var. *typicus*; *d, H. firmus* var. *stratiotes*; *e, H. firmus* var. *longipes* (Fraser's Hill, *vide* text); × 1000.

stage, is delayed and this part is further protruded into a subacute apex through the pressure in the basidium, and the process is carried farthest in the Macrosporae. In the Ovalisporae, var. *puniceoides* might be separated specifically from *H. firmus* var. *typicus* and var. *militaris* on the shape and colour of the fruit body and the rather smaller spores, which are most like those of *H. hypohaemactus*. In the Macrosporae, probably only var. *gracillimus* deserves specific rank. The varieties *longipes*, *minimus* and *pachyphyllus* are only growth forms. The remainder are chiefly colour forms in which the pigment is either limited to certain parts or modified into yellow, pink or purple. The varieties *stenophyllus* and *sericeus* combine differences both in colour and form.

H. similis Petch is macroscopically very like *H. firmus*, but its spores are monomorphous and narrowly ellipsoid or subcylindric, 6–9 × 3–3·5 (–4) µ. I have examined part of the type collection, Herb.

Perad. 5580. It seems very close to *H. Reai*, but I could make out no structural details in the dried specimen.

Finally it must be remarked that Petch's statement that the large spores of *H. firmus* are verrucose is an error. I have examined Herb. Perad. 2299, determined by Petch, and find the spores smooth. It is well known that a densely granular cytoplasm may give the appearance of a rough epispore when the spore wall is very thin and transparent, and an immersion lens is needed to decide the point.

Summary

Hygrophorus firmus and *H. hypohaemactus* sp.nov. form two kinds of basidiospore. In the same fruit body they produce large spores with dense contents on large basidia, and small spores of half the linear measure and with vacuolate contents on small basidia. The meaning of the dimorphism is unknown.

Both species occur in Malaya, *H. firmus* being known previously from Ceylon. *H. firmus* in Malaya is exceedingly variable. Sixteen varieties are proposed under two sections according to the spore character: most are colour varieties but some are shown to be juvenile forms, others to be overgrowths. *H. hypohaemactus* is rare.

H. hypohaemactus differs from *H. firmus* in the viscid pileus and stem and in the smaller less dimorphous spores. Both are related to the group of *H. miniatus*, *H. turundus*, etc. The systematic position is discussed.

The structure, development and variation in size of the fruit body are explained in detail.

The fruit body of *H. firmus* is gymnocarpic with exogenous pileus. There is a pile on the pileus, at least over the disc, but not on the stem. The gill edge is sterile with cheilocystidia: there are no pleurocystidia. Development is gradual, occupying about a fortnight. The growth of the primordial shaft takes two to three days. The stem and pileus slowly inflate acropetally during the next ten to twelve days. The mature fruit body lasts about a week, making the total life a little more than three weeks. Sporing begins about the sixth day when the pileus is 4–6 mm. wide. These observations were made in Singapore at a mean temperature of 80° F. (70–90° F.).

The limb and gills develop by apical growth of the hyphae followed by acropetal inflation, exactly as the primordial shaft. In the stem and pileus many hyphae do not inflate but are passively drawn out. Both kinds of basidium are borne on the same hyphae, the large basidia being the first formed and arising deeply in the subhymenium. The large spores are carried beyond the level of the small spores. The hymenium is aequihymeniiferous.

The fruit body of *H. hypohaemactus* is essentially similar, but the

hyphae of the pile on the pileus and those on the surface of the stem and in the subhymenium have mucilaginous walls, and there are peculiar hypha-like tramal cystidia with oleaginous contents in the gills.

I must, in conclusion, express my obligation to the Director of Agriculture, Ceylon, for the loan of authentic material and drawings of the several species of *Hygrophorus*.

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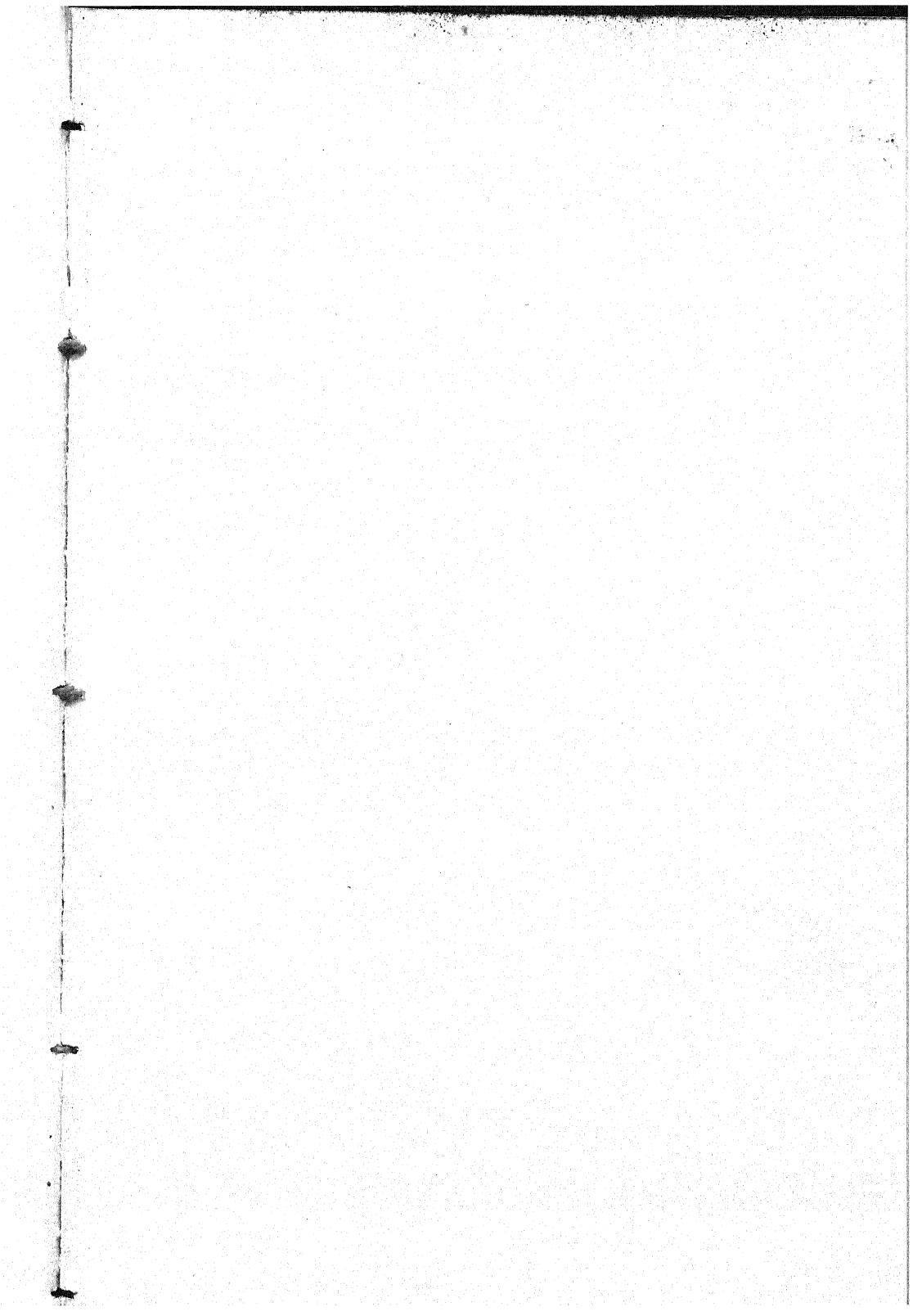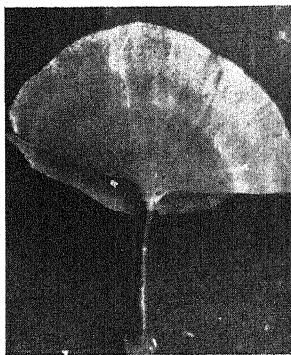
Fig. 1.

Fig. 2.　　　　　　Fig. 3.　　　　　　Fig. 4.
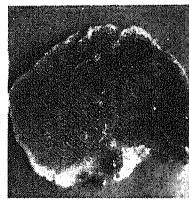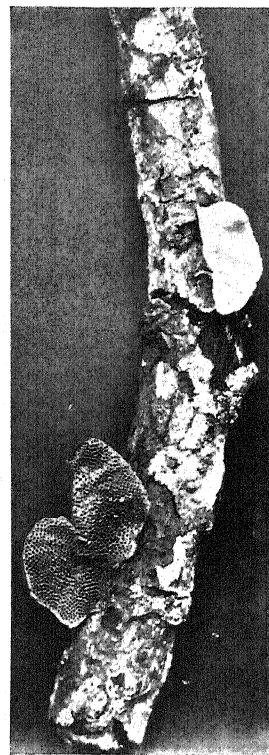
POLYSTICTUS XANTHOPUS
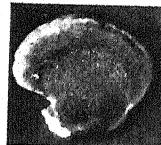
Fig. 5.　　　　　　Fig. 6.

POLYSTICTUS FLABELLIFORMIS

A NOTE ON THE VARIATION OF PORES OF *POLYSTICTUS XANTHOPUS* FRIES AND *POLYSTICTUS FLABELLIFORMIS* KL. AT HIGH ALTITUDES

By S. R. BOSE

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(With Plate II)

THE hymenial surface of specimens of *Polystictus xanthopus* Fr. at high altitudes shows three different kinds of porous areas, viz. some with typical very small pores, some with much bigger pores and some with hydnoid pores (Pl. II, figs. 1, 2 and 3). In one piece of dead branch of a tree, specimens with typical pores and hydnoid pores were growing not very far off from each other (Pl. II, fig. 4), and so it is concluded that they are variations of one and the same species. Such variations are hardly found in the plains where the fungus is abundant, with very small typical pores on the hymenial surface.

Specimens of *P. flabelliformis* Kl. similarly collected from high altitudes show two kinds of porous surface, some with very small pores and others with much bigger pores (Pl. II, figs. 5 and 6). In other respects, morphological and anatomical, the specimens are exactly similar. In the plains we always get them with small pores on the hymenial surface.

This illustrates, as has been noted by French mycologists (Sauger, Josserand, Maire, etc.), that the dimension of the pores in the hymenial surface—one particular character—is not always a safe guide in the delimitation of species.

The specimens described in this note were collected from high hills of four different localities: (1) Cherrapunji, Assam, by me (8000 ft. elevation) in March, 1929; (2) Lokra hills (8000–10,000 ft. elevation) by Dr N. L. Bor in January, 1934; (3) Bhutan border (10,000 ft. elevation) by Mr K. P. Biswas, Curator of the Shibpur Herbarium Royal Botanic Gardens, in April 1934; (4) Pareshnath hills (2000 ft.) by Mr K. P. Biswas in November 1934.

NOTE ON ABNORMAL SPORES IN
PODOSPORA MINUTA

By WINIFRED M. PAGE, M.Sc.

(With 5 Text-figures)

PODOSPORA MINUTA occurs commonly on rabbit pellets. It appears early in the succession of fungi, usually fruiting at the same time as *Ascophanus carneus* and other Discomycetes.

The spores germinate readily and single-spore cultures are easily obtained.
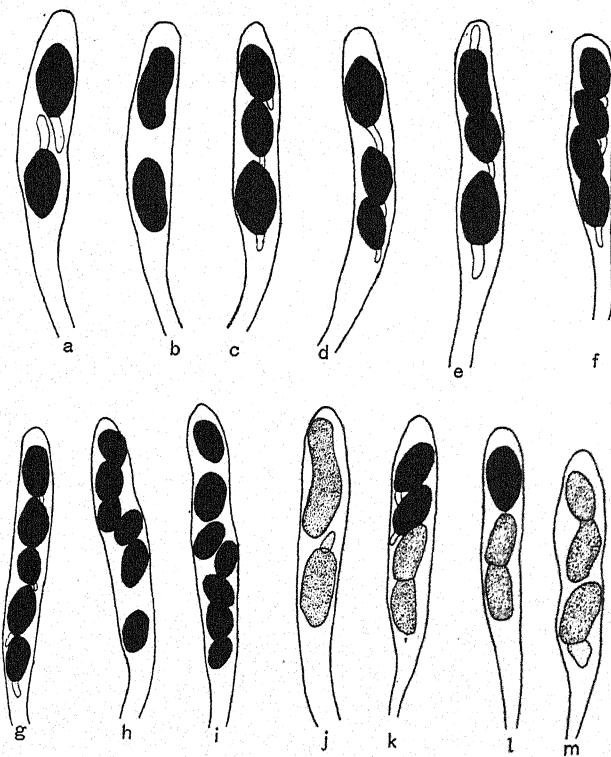
Fig. 1. Types of asci showing variation in number of spores and abnormal spores. × 200.

The normal asci contain four spores, each of which is capable of producing a mycelium giving rise to fruits (Fig. 1*f*). In perithecia grown in culture and also in those growing on rabbit pellets collected

from various sources, asci with abnormal spores sometimes occur. From one to seven spores which, apart from size, are normal in appearance have been observed (Fig. 1 *a–i*). In addition irregular spores, some of which never completely darken, are occasionally

	1	3	4	5	2	6	7
1					●	●	●
3					●	●	●
4					●	●	●
5					●	●	●
2	●	●	●	●			
6	●	●	●	●			
7	●	●	●	●			

Fig. 2. Table showing results of crossing mycelia from A and B spores.
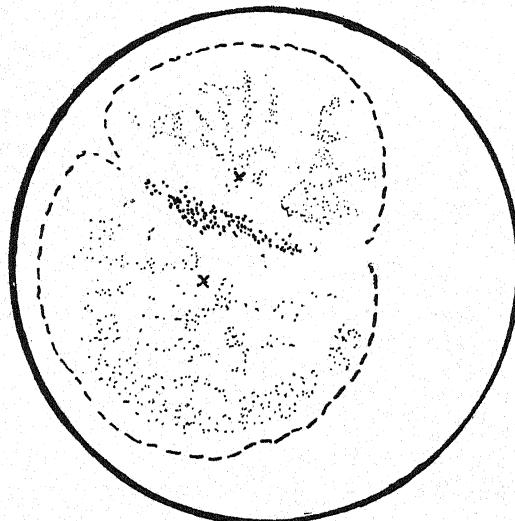
Fig. 3. Diagram from photograph of culture from A and B spores. Points of inoculation indicated by ×. The fine dots show abortive perithecia and the broken lines the limits of the mycelia.

seen (Fig. 1 *j–m*). Of asci with other than four spores, the one giant and two normal is the most common variety (Fig. 1 *c–e*). Asci with two dwarf and three normal spores are not so frequent, but a number of the dwarf spores have been isolated and germinated (Fig. 1 *g*). As in *Sordaria fimicola* (four-spored form) the perithecium initials in

the mycelia from these spores never mature. When the spherical stage is reached no further development takes place (4, 5, 6).

The mycelia from these dwarf spores were found to be of two different, but complementary, strains. A number of crosses were
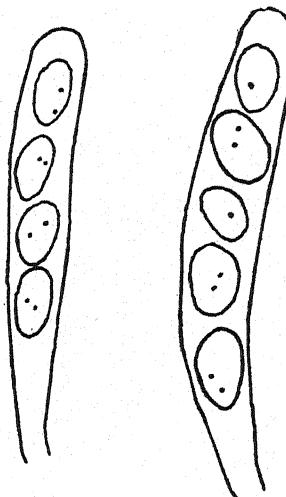
Fig. 4. Sections of young four- and five-spored asci showing nuclei. × 400.
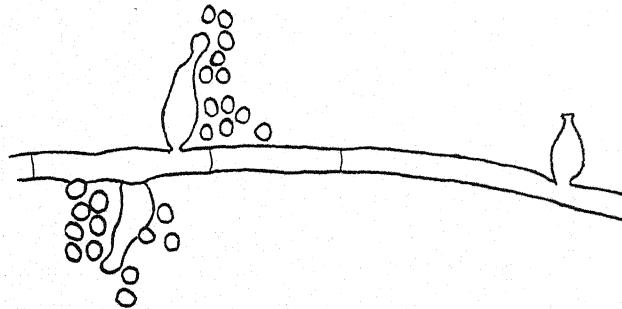
Fig. 5. Formation of small colourless spores. × 1600.

made and the results are shown in the table (Fig. 2). The details of the results agree with those of *Sordaria fimicola* (6).

The normal spores contain two nuclei and the dwarf spores one nucleus each (Fig. 4).

The eight-spored form of this fungus is not common; I have found it only once in many years of collecting. It was, however, cultured. Each of the eight spores is uninucleate and capable of producing mycelia which fruit.

In the four-spored variety very tiny colourless spores are produced, being cut off from flask-shaped outgrowths (Fig. 5). These have been seen in normal cultures and also in those from dwarf spores. Work on these spores is now in progress, and up to the present there has been no indication that they possess the functions predicated for the "micro-conidia" by Ames in *Podospora (Pleurage) anserina*(1, 2, 3). The perithecium initials, whether normal or abortive, early send out branches to form secondary mycelia, but there is no evidence that any of these can be described as a trichogyne.

It is interesting to note that Winter in 1873 figured an ascus with two spores in *Sordaria (Podospora) anserina*(7).

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A SIMPLE METHOD OF PRESERVING AND MOUNTING SPECIMENS OF FUNGAL LESIONS ETC. FOR DEMONSTRATION

By N. C. PRESTON

Wʜᴇɴ engaged on infection experiments with *Myrothecium roridum* I had need of specimens of the lesions produced on stem and leaves which would remain fresh and demonstrable over a considerable period and which could be easily transported. The procedure here described was therefore adopted with considerable success and, since it is extremely simple and is very rapidly carried out, it is thought that this brief description will be of interest to other workers.

A 2 per cent. solution of agar containing about 0·1 per cent. mercuric chloride is prepared and poured into Petri dishes of suitable size. When this has cooled to near solidifying point the leaves or other pieces of tissue are plunged, without previous preparation, directly into the agar and held beneath the surface with a warm needle until the mass has solidified sufficiently to retain them in position. The depth of agar in the dish will of course depend upon the thickness of the object to be embedded and should be just sufficient to cover it evenly. The agar must not be used too hot or the colour of the material will be lost.

Specimens prepared in this way will keep for many months, retaining their natural appearance even after the agar has become dry and hard. The method of mounting also has the advantage that both sides of the object can be closely examined since the lid of the dish may be safely removed without fear of mould contaminations. In specimens kept unsealed for six months hyphae and spores of the sporodochia present upon the leaves were still easily visible under a $\frac{1}{6}$ in. objective.

NOTES ON TYPE SPECIMENS OF BRITISH INOPERCULATE DISCOMYCETES

(FIRST PART, NOTES 1–50)

By J. A. NANNFELDT
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A GRANT from the University of Upsala (C. F. Liljewalch's resesti-pendium) made it possible for me to visit London in the summer of 1932 in order to study Discomycetes in the herbaria of the British Museum (Natural History) and of the Royal Botanic Gardens, Kew. When comparing a British fungus flora with one from the Continent one is struck by the number of species described from Britain and not known outside it. After studying the types of those British species I was able to establish the fact that most of them have been known for a long time on the Continent also, though under different names.

My main interest was devoted to the inoperculates, and in these notes the results of my examination of fifty British species of that group are given. The preparation of the list has been much delayed for various reasons, but I hope to be able to continue it soon. My work in London was greatly facilitated by the courtesy shown to me by the officials, and I wish to express my profound gratitude to them all.

In this paper the species are arranged alphabetically, according to the names in Ramsbottom's List of British Discomycetes (*Trans. Brit. mycol. Soc.* IV). For the convenience of the reader, the synonymy and citations to the British fungus floras as well as to Saccardo's *Sylloge Fungorum*, Rehm's *Discomyceten*, and Boudier's *Discomycètes d'Europe* are appended. For further information references are frequently given to v. Höhnel's numerous papers (his "Fragmente zur Mycologie" being cited as "Fr. z. M." and his "Mycologische Fragmente" as "M. Fr.") and to my own work: "Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten" in *Nova Acta Reg. Soc. Sci. upsal.* Ser. IV, vol. VIII, No. 2 (cited as Nannfeldt, 1932).

1. **Belonidium Jerdoni** (Cke. & Phill.) Massee, *Brit. F. Fl.* IV, 229.
   Peziza Jerdoni Cke. & Phill. in sched.

   This name, as well as *Hyalinia incarnata* (Cke.) Boud. (note 15), is a synonym for *Pseudohelotium pineti* (Batsch ex Fr.) Fuck. This gathering was listed by Phillips as *Mollisia lurida* (Pers.) Phill. and declared to

be quite distinct from *Peziza pineti* Batsch. Phillips based his identification on a Fries specimen at Kew, labelled *P. lurida*. Massee took up a herbarium name by Cooke & Phillips for the fungus in question, stating that it is different from *P. pineti* Batsch = *P. lurida* Pers. I have studied the type of *P. Jerdoni* as well as the Fries specimen. They are both typical *Pseudohelotium pineti* as understood by v. Höhnel (Fr. z. M. No. 1224) who points out the very large variability in the shape and size of the spores of this species.

No specimen of *Peziza lurida* is to be found in Herb. Persoon (at Leyden), but the description leaves no doubt that he had the same fungus in mind.

2.   **Belonium Arctii** (Phill.) Sacc. *Syll. F.* VIII, 495 (No. 2044); Boud.
      Discom. d'Eur. p. 118.

   Peziza (Mollisia) Arctii Phill. ap. Buckn. in *Proc. Bristol Nat. Soc.*
      N.S. IV, 58.
   Mollisia Arctii Phill. *Brit. Discom.* p. 183.
   Belonidium Arctii Massee, *Brit. F. Fl.* IV, 225.
   Pyrenopeziza Arctii Nannf. in *Nova Acta Reg. Soc. Sci. upsal.* Ser. IV,
      vol. VIII, No. 2, p. 142.

The type specimen, as well as the specimens distributed in Vize, *Micro. f. brit.* No. 476, are identical with the fungus I recently published as *Pyrenopeziza Arctii* (Phill.) Nannf. Until then it was recorded only from the type locality, but I have found it to be fairly common in Sweden.

3.   **Belonium filisporum** (Cke.) Sacc. *Syll. F.* VIII, 494 (No. 2039);
      Boud. *Discom. d'Eur.* p. 118.

   Peziza (Mollisia) filispora Cke. in *Grev.* III, 66.
   Belonidium filisporum Phill. *Brit. Discom.* p. 152; Massee, *Brit. F. Fl.*
      IV, 226.
   Trichobelonium filisporum Rehm in *Ber. bayer. bot. Ges.* XIV, 107.

This species is said in the original description to grow "on sheaths of grass". The type specimen (in Herb. Kew.) shows that the grass is *Brachypodium sylvaticum* and the fungus is identical with *Belonopsis pallens* (Sacc.) Keissl. (For description and synonymy of this species see Nannfeldt, 1932, p. 104.) As Cooke's specific epithet antedates that of Saccardo, the fungus should be called *Belonopsis filispora* (Cke.) Nannf. n.comb.

The same species is preserved in Phillips's herbarium (Brit. Mus.) as "*Belonidium albido-virella* n.s. ined."

4.   **Calloria coniicola** Cke. & Phill. ap. Phill. *Brit. Discom.* p. 333;
      Sacc. *Syll. F.* VIII, 639 (No. 2637); Massee, *Brit. F. Fl.* IV, 152;
      Boud. *Discom. d'Eur.* p. 101.

Judging from descriptions only, I have suggested that this species might belong to the genus *Laetinaevia* Nannf. (Nannfeldt, 1932, p. 191). The examination of the type specimen showed that the descriptions are very insufficient and that my suggestion was wrong. It is a very delicate *Lachnum*, which—so far as I understand—cannot be specifically separated from *L. brevipilum* v. Höhn.

5. ***Calloria cornea*** (B. & Br.) Phill. *Brit. Discom.* p. 332; Sacc. *Syll. F.* VIII, 640 (No. 2639); Massee, *Brit. F. Fl.* IV, 152; Boud. *Discom. d'Eur.* p. 101.

   Peziza cornea B. & Br. in *Ann. Mag. nat. Hist.* (2), VII, 183 (No. 578); Berk. *Outl.* p. 371; Cke. *Handb.* p. 704 (No. 2113).

This species has been studied by v. Höhnel (e.g. Fr. z. M. No. 1074), who considered it to be a *Mollisia, M. cornea* (B. & Br.) v. Höhn. I supported this view (Nannfeldt, 1932, p. 126), and gave drawings of the excipulum. v. Höhnel's opinion—as well as mine—was based solely on the study of specimens distributed in Rabenhorst's *Fungi europaei*. The type specimen is identical with these.

6. ***Calloria fusarioides*** (Berk.) Fr. *S. Veg. Scand.* p. 359; Phill. *Brit. Discom.* p. 331; Rehm, *Discom.* p. 463; Sacc. *Syll. F.* VIII, 639 (No. 2634); Massee, *Brit. F. Fl.* IV, 151; Boud. *Discom. d'Eur.* p. 101.

   Peziza fusarioides Berk. in *Mag. ?ool. Bot.* 1, 46 (No. 12); Berk. *Outl.* p. 371; Cke. *Handb.* p. 704 (No. 2114).

This species has always been interpreted correctly. A very full description is given by v. Höhnel (Fr. z. M. Nos. 1063–4).

7. ***Calycella claroflava*** (Grev.) Boud. *Discom. d'Eur.* p. 95.

   Peziza claroflava Grev. *Fl. Edin.* p. 424; Berk. in *Engl. Fl.* v, pt. 2, p. 203.

   Helotium claroflavum Berk. *Outl.* p. 372; Cke. *Handb.* p. 713 (No. 2150); Phill. *Brit. Discom.* p. 165; Sacc. *Syll. F.* VIII, 225 (No. 914); Massee, *Brit. F. Fl.* IV, 233.

In Herb. Kew. I saw what may be the specimen referred to by Massee, viz. one labelled in Cooke's handwriting: "*Helotium claroflavum*—ex Grev." This specimen, as well as numerous others both at Kew and in Brit. Mus., is typical young *Calycella citrina* (Hedw. ex Fr.) (= *Helotium citrinum* Fr.). In this connection the following note by Phillips is of a certain interest: "Most of my British specimens are immature" (in litt. ad Cooke, 18. v. 1876). The immaturity of the apothecia is evidently the cause of the small size of the spores.

8. **Calycella flava** (Klotzsch) Boud. *Discom. d'Eur.* p. 95.

   Peziza flava Klotzsch in sched.
   Helotium flavum Phill. *Brit. Discom.* p. 156; Sacc. *Syll. F.* VIII, 225 (No. 915); Massee, *Brit. F. Fl.* IV, 241.

The type specimen, which was very fully described by Massee, in my opinion represents typical *Calycella citrina* (Hedw. ex Fr.). It differs only externally by the somewhat horny, semitranslucent apothecia of a more uniform yellowish white. In winter, after frost, the apothecia of *C. citrina* undergo, however, just these changes. As to anatomical structure, asci and spores no differences could be detected.

9. **Cudoniella Allenii** A. L. Sm. in *Trans. Brit. mycol. Soc.* III, 40; Sacc. *Syll. F.* XXII, 603 (No. 5331).

The type specimen in Herb. Mus. Brit. is typical *Corynella atrovirens* (Pers.) Boud. The apothecia are remarkably well developed with convex hymenium, and their stemlike bases are somewhat more conspicuous than usual.

It will be shown below that *Pachydisca agaricina* (Carm. ap. Berk.) Boud. (note 30) and *Pithyella hydnicola* (B. & Br.) Boud. (note 39) are also *Corynella atrovirens*.

10. **Dasyscypha campylotricha** A. L. Sm. in *Trans. Brit. mycol. Soc.* III, 112; Sacc. *Syll. F.* XII, 684 (No. 5616) ("campylotrichia").

This species belongs to the genus *Unguiculella* v. Höhn. The specimens distributed by Karsten in F. Fenn. No. 652 (on *Artemisia vulgaris*) as *Peziza eurotioides* Karst. are the same fungus. It is evidently very rare, collected only in the type gatherings.* Its correct name is *Unguiculella eurotioides* (Karst.) Nannf. n.comb.

11. **Dasyscypha crucifera** (Phill.) Sacc. *Syll. F.* VIII, 440 (No. 1833); Massee, *Brit. F. Fl.* IV, 331; Boud, *Discom. d'Eur.* p. 119.

   Peziza crucifera Phill. in *Gard. Chron.* (1878), p. 397.
   Lachnella crucifera Phill. *Brit. Discom.* p. 250.

This species belongs—as the descriptions also bear witness—to the genus *Lachnum* Karst., and its correct name is *Lachnum cruciferum* (Phill.) Nannf. n.comb.

As far as I am aware, this fungus has never been reported from outside Britain, but I have seen it several times in Sweden and think it is common everywhere on *Myrica Gale*.

12. **Discinella exidiiformis** (B. & Br.) Boud. *Discom. d'Eur.* p. 96.

   Peziza exidiiformis B. & Br. in *Ann. Mag. nat. Hist.* (4), XV, 37 (No. 1480); Cke. *Mycogr.* f. 60; Phill. *Brit. Discom.* p. 81; Massee in *J. linn. Soc. (Bot.)*, XXXI, 501.

* My report of *Peziza eurotioides* from Sweden (*Svensk bot. Tidskr.* XXII, 131 as *Pezizella eurotioides*) is based upon an erroneous determination.

Humaria exidiiformis Sacc. *Syll. F.* VIII, 122 (No. 468); Massee,
    Brit. F. Fl. IV, 418.

This species belongs to the operculate Discomycetes, probably to
the genus *Humaria* (= *Humarina* Seav.), as Saccardo and Massee
(*Brit. F. Fl.*) suggested.

13. **Encoelia Bloxami** (Berk.) Phill. *Brit. Discom.* p. 338; Boud.
    Discom. d'Eur. p. 161.

    Patellaria Bloxami Berk. in sched.
    Cenangium Bloxami Sacc. *Syll. F.* VIII, 568 (No. 2343); Massee,
    Brit. F. Fl. IV, 114.

As noted already by Massee on the type specimen (at Kew), this
species is identical with *Diplocarpa Curreyana* Massee.

14. **Habrostictis lasia** (B. & Br.) Boud. *Discom. d'Eur.* p. 102.

    Peziza lasia B. & Br. in *Ann. Mag. nat. Hist.* (4), II, 347 (No. 1391).
    Calloria lasia Phill. *Brit. Discom.* p. 327.
    Orbilia lasia Sacc. *Syll. F.* VIII, 625 (No. 2574); Rehm, *Discom.*
    p. 456; Massee, *Brit. F. Fl.* IV, 146.

This species was treated earlier both by v. Höhnel (Fr. z. M.
No. 1016) and myself (Nannfeldt, 1932, p. 97), but we did not study
the actual type. The type specimen proves to be identical with the
species treated by us and generally known as *Habrostictis lasia* (B. &
Br.) Boud. or *H. rubra* Fuck. The latter is the valid name.

15. **Hyalinia incarnata** (Cke.) Boud. *Discom. d'Eur.* p. 103.

    Peziza (Mollisia) incarnata Cke. in *Grev.* I, 131.
    Mollisia incarnata Phill. *Brit. Discom.* p. 191; Massee, *Brit. F. Fl.*
    IV, 216.
    Pezizella incarnata Sacc. *Syll. F.* VIII, 285 (No. 1186).

The type specimen (in Herb. Kew.) is in a rather bad condition
and very poor, but it allows of the certain identification of this species
as *Pseudohelotium pineti* (Batsch ex Fr.) Fuck. Further notes on this
species are given above under *Belonidium Jerdoni* (Cke. & Phill.)
Massee (note 1).

16. **Lachnella canescens** (Cke.) Phill. *Brit. Discom.* p. 259; Sacc.
    Syll. F. VIII, 394 (No. 1620); Boud. *Discom. d'Eur.* p. 123.

    Peziza canescens Cke. in litt. ad Phill.
    Dasyscypha canescens Massee, *Brit. F. Fl.* IV, 346.

Phillips placed this species next to *Lachnella corticalis* Fr. but con-
sidered it specifically distinct because of its somewhat different spores
and "the more conspicuous septate hairs of the exterior". Examination
of the type specimen (at Kew) proved that the alleged differences are
very slight, if any, and fall within the variation shown by *L. corticalis*.

I have shown (Nannfeldt, 1932, p. 265) that the generic name *Lachnella* cannot be used in this sense, and that the species is a *Lachnum, L. corticale* (Pers. ex Fr.) Nannf.

17. **Lachnella Crosslandi** Boud. ap. Ramsb. in *Trans. Brit. mycol. Soc.* IV, 375.

Echinella Crosslandi Massee, *Brit. F. Fl.* IV, 306.

Pirottaea Crosslandi Sacc. in *Hedw.* XXXV, Beih. 7, p. xxxvi; Sacc. *Syll. F.* XIV, 776 (No. 2913).

The type specimen (at Kew) is *Lachnum corticale* (Pers. ex Fr.) Nannf. (see Nannfeldt, 1932, pp. 129 and 265) with unusually well-developed spores.

18. **Lachnella (Helotiella) Laburni** Phill. in *Scot. Nat.* (1891), p. 90; A. L. Smith in *Trans. Brit. mycol. Soc.* IV, 76.

Helotiella Laburni "A. L. Sm." Sacc. *Syll. F.* XXIV, 1209 (No. 7267).

The type specimen (at Brit. Mus.) is very poor. The only Discomycete that I could find on it was *Unguicularia scrupulosa* (Karst.) v. Höhn. Phillips's description matches it tolerably, except for the asci and the spores. It is impossible to tell whether he made mistakes when measuring them or studied a mixture of two species.

19. **Lachnella setulosa** (Massee & Crossl.) Boud. ap. Ramsb. in *Trans. Brit. mycol. Soc.* IV, 375.

Echinella setulosa Massee & Crossl. ap. Massee, *Brit. F. Fl.* IV, 305.

Pirottaea setulosa Sacc. in *Hedw.* XXXV, Beibl. 7, p. xxxvi; Sacc. *Syll. F.* XIV, 776 (No. 2912).

I have recently suggested that this species might be identical with *Trichobelonium obscurum* Rehm (Nannfeldt, 1932, p. 167). In Crossland's herbarium (now at Kew) there may be found not only the type collection but also seven additional gatherings. They are all identical with Rehm's species. *T. obscurum* Rehm is the valid name.

20. **Lachnella siparia** (B. & Br.) Phill. *Brit. Discom.* p. 276; Sacc. *Syll. F.* VIII, 396 (No. 1629); Boud. *Discom. d'Eur.* p. 123.

Peziza (Fibrina) siparia B. & Br. in *Ann. Mag. nat. Hist.* (2), XIII, 465 (No. 772); Berk. *Outl.* p. 370; Cke. *Handb.* p. 696 (No. 2079).

Dasyscypha siparia Massee, *Brit. F. Fl.* IV, 367.

The type (at Kew and Brit. Mus.) shows that *Peziza siparia* is a true *Encoelia* (Fr.) Karst. (see Nannfeldt, 1932, pp. 303–4) and identical with *Cenangium Ulmi* Tul. The British specimens are not—as Berkeley & Broome state—"on decorticated elm branches" but on

the inner bark of elm. As the specific epithet "*siparia*" antedates "*Ulmi*", the species should be known as *Encoelia siparia* (B. & Br.) Nannf. n.comb.

21. **Lecanidion clavisporum** (B. & Br.) Sacc. & D. Sacc. ap. Sacc. *Syll. F.* xviii, 184 (No. 3808); Boud. *Discom. d'Eur.* p. 154.

Patellaria clavispora B. & Br. in *Ann. Mag. nat. Hist.* (2), xiii, 465 (No. 774); Berk. *Outl.* p. 373; Cke. *Handb.* p. 717 (No. 2166); Phill. *Brit. Discom.* p. 366; Massee, *Brit. F. Fl.* iv, 102; Massee in *J. linn. Soc.* (*Bot.*), xxxv, 107.

Durella clavispora Sacc. *Syll. F.* viii, 794 (No. 3257).

Two authentic gatherings of this species were seen by me, viz. the type collection from Lucknam Grove (at Kew and Brit. Mus.) and a second gathering from St Catharine's (Herb. Broome in Brit. Mus.). They are both identical with *Lecanidion Crataegi* (Phill.) Sacc. (see next entry) and *Patellaria corticola* Starb.

I have published a photomicrograph of *P. corticola* and pointed out (Nannfeldt, 1932, p, 196) that it shows no relationship to the genus *Patellaria*. I know no other genus where it could be placed, and its affinity is still obscure to me.

22. **Lecanidion Crataegi** (Phill.) Sacc. *Syll. F.* viii, 799 (No. 3276); Boud. *Discom. d'Eur.* p. 155.

Patellaria Crataegi Phill. in *Grev.* xvii, 46; Massee, *Brit. F. Fl.* iv, 106.

In Herb. Phillips (at Brit. Mus.) are preserved two specimens under this name, both collected by Trail. The type specimen ("No. 3—on hawthorn twigs—Corbie Den—1. ii. 89") is identical with *Lecanidion clavisporum* (B. & Br.) Sacc. & D. Sacc. (see preceding entry). The second specimen ("No. 15—on bramble—nr Aberdeen—4. iii. 87") is a long-spored *Durella*.

The Romell specimen (Sweden: Gotland, Visby, 1. vii. 1887) in Herb. Kew. to which Massee (*loc. cit.*) alludes, is also *Lecanidion clavisporum*.

23. **Lecanidion Hyperici** (Phill.) Sacc. *Syll. F.* viii, 801 (No. 3288); Boud. *Discom. d'Eur.* p. 155.

Patellaria Hyperici Phill. in *Grev.* x, 69; Phill. *Brit. Discom.* p. 363; Massee, *Brit. F. Fl.* iv, 107.

This species, which is distributed in Phill. *Elv. Brit.* No. 191, is identical with *Durella atrocyanea* (Fr.) v. Höhn. (= *Stictis atrocyanea* Fr.). The apothecia are situated in greenish spots as they usually are in that species, though this feature was not mentioned in any description of *Patellaria Hyperici*. For further particulars about the very much misunderstood *Durella atrocyanea* see v. Höhnel, *Ann. mycol.*, Berl., xvi, 210–12.

24. **Lecanidion Lonicerae** (Phill.) Sacc. *Syll. F.* VIII, 797 (No. 3267);
    Boud. *Discom. d'Eur.* p. 155.

    Patellaria Lonicerae Phill. *Brit. Discom.* p. 364; Massee, *Brit. F. Fl.*
    IV, 104.

No specimen, but only a drawing was to be found in Phillips's
herbarium (at Brit. Mus.). A specimen in Cooke's herbarium (at
Kew), labelled by Phillips "*Patellaria Lonicerae* n.s.—On honey-
suckle—Darnaway, N.B." is evidently part of the type material. The
fungus is a true *Durella*, which I am unable to separate from *D. vilis*
Starb. As Phillips's name is the older, the valid name of the species
is *D. Lonicerae* (Phill.) Nannf. n.comb. (see Nannfeldt, 1932, p. 293).

25. **Mollisia atrocinerea** (Cke.) Phill. *Brit. Discom.* p. 176; Sacc.
    Syll. F. VIII, 322 (No. 1334); Massee, *Brit. F. Fl.* IV, 208;
    Boud. *Discom. d'Eur.* p. 136 (non Rehm, *Discom.* p. 530).

    Peziza atrocinerea Cke. *F. Brit. Exs.* Ed. ii, no. 382.

As both Massee (*loc. cit.*) and Morgan (*J. Mycol.* VIII, 182) have
already suggested, this species, on *Polygonum*, is identical with the
older *Mollisia Polygoni* (Lasch) Rehm. Rehm lists a *M. atrocinerea*
(Cke.) Phill. which he regards as very closely allied to *M. atrata*
(Pers. ex Fr.) Karst. and to *M. revincta* Karst. Rehm's species grows
on stems of several different herbs but not on *Polygonum*. His her-
barium shows that he placed numerous different fungi under this
name as well as under *Mollisia atrata*.

M. Polygoni is a very characteristic species, differing in many re-
spects from both *Mollisia* and *Pyrenopeziza*. Probably it should be
placed in a separate genus of its own, but the time is not yet ripe
for a definite system of Mollisioideae.

26. **Mollisia Browniana** (Blox. ap. B. & Br.) Sacc. *Syll. F.* VIII, 327
    (No. 1355); Boud. *Discom. d'Eur.* p. 137.

    Peziza (Mollisia) Browniana Blox. ap. B. & Br. in *Ann. Mag. nat.
    Hist.* (3), XV, 446 (No. 1072); Cke. *Handb.* p. 702 (No. 2102);
    Phill. *Brit. Discom.* p. 408.

    Pseudopeziza Browniana Massee, *Brit. F. Fl.* IV, 199.

Examination of the type collection (at Kew and Brit. Mus.) proved
that this species has been totally misinterpreted. The fungus is *Hetero-
sphaeria Patella* Grev., and the substratum is not *Epilobium hirsutum* but
some kind of Umbelliferous plant, almost certainly *Angelica silvestris*.

27. **Niptera Stockii** (Cke. & Phill.) Boud. *Discom. d'Eur.* p. 141.

    Peziza Stockii Cke. & Phill. in sched.
    Lachnella Stockii Phill. *Brit. Discom.* p. 261.
    Belonium Stockii Sacc. *Syll. F.* VIII, 496 (No. 2048).
    Echinella Stockii Massee, *Brit. F. Fl.* IV, 307.

The type specimen (at Kew) is in a very bad condition. It could be ascertained, however, that the fungus belongs to the genus *Pyrenopeziza* Fuck. emend. Nannf. It has septate spores and the margin of the excipulum passes into long, obtuse, hyaline hairs. The taxonomic position is next to *P. Arctii* (Phill.) Nannf. and *P. leucostoma* (Karst.) Nannf. Its identity must be left undecided until the host plant can be determined. It is probably a Composite.

28. **Orbilia Boydii** A. L. Sm. & Ramsb. in *Trans. Brit. mycol. Soc.* II, 168; Sacc. *Syll. F.* xxiv, 1239 (No. 7370).

The type specimen (in Herb. Brit. Mus.) as well as another authentic specimen ("on dead twigs of *Vaccinium Myrtillus*—Beith, Ayrshire—20th July 1912—D. A. Boyd") both show a very young, hardly ripe *Pezicula*, which can with certainty be identified with *P. myrtillina* Karst.

29. **Orbilia scotica** Massee, in *Grev.* xxii, 99; Massee, *Brit. F. Fl.* iv, 144; Sacc. *Syll. F.* xi, 426 (No. 2661); Boud. *Discom. d'Eur.* p. 103.

In the original description of this species Massee gives the information that it is based on a specimen from "Aboyne, N.B." lying in the Berkeley herbarium at Kew as *Peziza vinosa*. On a sheet of *Orbilia vinosa* there, I found a specimen marked in Berkeley's handwriting: "*Pez. (Mollisia)*—Aboyne, Sept. 1870." In my opinion this specimen must be the type, though it bears no note at all in Massee's hand. It matches the description of *Orbilia scotica* very well, except for the spores. These were extremely difficult to see, as they usually are in herbarium specimens of *Orbilia*, and the poorness of the material did not permit studying more than one apothecium. Nevertheless, I was able to find a few genuine free spores which were undoubtedly ascospores. They were needle-shaped and about 12×1–$1 \cdot 5 \mu$. I have no hesitation in saying that Massee's description of the spores as "elliptic-oblong, ends obtuse, $4 \times 1 \mu$" was due to faulty observation. *O. scotica* is identical with the species that W. Nylander (*Not. Sällsk. F. Fl. Fenn. Förh.* x, 56) described as *Peziza vinosa* A. & S. and that has later been known as *Orbilia vinosa* (A. & S.) Karst. It is a typical *Orbilia*, but it is impossible to decide whether it is identical with the original *Peziza vinosa* of Albertini & Schweinitz.

30. **Pachydisca agaricina** (Carm. ap. Berk.) Boud. *Discom. d'Eur.* p. 93.
   Peziza agaricina Carm. ap. Berk. in *Engl. Fl.* v, pt. 2, p. 207.
   Helotium agaricinum Berk. *Outl.* p. 371; Cke. *Handb.* p. 708 (No. 2127); Sacc. *Syll. F.* viii, 220 (No. 896).
   Belonidium agaricinum Massee, *Brit. F. Fl.* iv, 224.

The type specimen (in Herb. Kew.) proved to be *Corynella atrovirens* (Pers.) Boud.

31. **Pachydisca brunnea** (Phill.) Boud. *Discom. d'Eur.* p. 94.

> *Ombrophila brunnea* Phill. in *Grev.* VIII, 103; Phill. *Brit. Discom.* p. 323; Sacc. *Syll. F.* VIII, 619 (No. 2551); Massee, *Brit. F. Fl.* IV, 143.

This species belongs to the operculates and probably to the genus *Humaria* (= *Humarina* Seav.), but nothing definite about its identity can be said for the present.

32. **Pachydisca Laburni** (B. & Br.) Boud. *Discom. d'Eur.* p. 94.

> *Helotium Laburni* B. & Br. in *Ann. Mag. nat. Hist.* (4), XVII, 143 (No. 1624); Sacc. *Syll. F.* VIII, 249 (No. 1027); Massee, *Brit. F. Fl.* IV, 235; Massee in *J. linn. Soc. (Bot.)*, XXXI, 475.
> *Hymenoscypha Laburni* Phill. *Brit. Discom.* p. 135.

Rehm (*Discom.* p. 787) identified this species with the older *Helotium infarciens* Ces. & deNot. This identification is correct.

33. **Pachydisca ochracea** (Grev.) Boud. *Discom. d'Eur.* p. 93.

> *Peziza ochracea* Grev. *Scott. Crypt. Fl.* pl. 5; Berk. *Engl. Fl.* v, pt. 2, p. 204.
> *Helotium ochraceum* Berk. *Outl.* p. 372; Cke. *Handb.* p. 713 (No. 2148); Phill. *Brit. Discom.* p. 169; Sacc. *Syll. F.* VIII, 229 (No. 937); Massee, *Brit. F. Fl.* IV, 237.

The type of this species is evidently lost, and Massee based his description on the original one, adding microscopical details from a Carmichael specimen (determined by Klotzsch) in Herb. Kew. This specimen is still there, but I could detect no Discomycete on it. If one may make a guess from Greville's drawing and description, I should suggest that they represent some species of *Pezicula*, tentatively *P. livida* (B. & Br.) Rehm. The description of the hymenium "as if sprinkled with minute shining particles not unlike small grains of brown sugar", strongly suggests that genus (see Nannfeldt, 1932, p. 90).

Massee's description of the microscopical features indicates that the Carmichael specimen also belonged to the genus *Pezicula*.

Specimens in Herb. Brit. Mus. from Broome's herbarium marked "*Peziza ochracea*—Hartham Park—21. iii. 43", are old *Calycella citrina* (Hedw. ex Fr.).

34. **Pachydisca quisquilaris** (Phill.) Boud. *Discom. d'Eur.* p. 94.

No such species was ever described, Boudier's reference "*quisquilaris* Phill., *Grev.* XVI, p. 94—Sacc. *Syll. F.* VIII, p. 617" being a mixture of *Helotium quisquiliaris* Karst. and *Ombrophila helotioides* Phill.

35. **Pachydisca scoparia** (Cke.) Boud. *Discom. d'Eur.* p. 94.
   Helotium scoparium Cke. in *Grev.* IV, 111; Phill. *Brit. Discom.* p. 168; Sacc. *Syll. F.* VIII, 239 (No. 974); Massee, *Brit. F. Fl.* IV, 234.

   The type specimen at Kew represents a typical *Pezicula Rubi* (Lib.) Niessl, but the apothecia have (from age or bad preservation) lost most of their characteristic colour. It proved, on microscopical examination, to be unchanged internally.

36. **Patinella Euphorbiae** (B. & Br.) Sacc. *Syll. F.* VIII, 771 (No. 3171); Boud. *Discom. d'Eur.* p. 146.
   Peziza (Patella) Euphorbiae B. & Br. in *Ann. Mag. nat. Hist.* (5), III, 212 (No. 1829).
   Mollisia Euphorbiae Phill. *Brit. Discom.* p. 198.
   Pseudopeziza Euphorbiae Massee, *Brit. F. Fl.* IV, 197.

   I have studied the type specimen in Herb. Brit. Mus. The species proves to be identical with *Naevia tithymalina* (J. Kze.) Rehm (= *Calloria tithymalina* J. Kze.). The material is old and in bad condition; hence the dark colour.
   Kunze's specific epithet antedates "*Euphorbiae*" by three years. The correct taxonomic position of the fungus is not clear, though I believe it to be closely related to my genus *Laetinaevia* (see Nannfeldt, 1932, pp. 190–2).

37. **Peristomialis Berkeleyi** Boud. *Discom. d'Eur.* p. 116.
   Peziza (Mollisia) peristomialis B. & Br. in *Ann. Mag. nat. Hist.* (3), XVIII, 126 (No. 1169); Cke. *Handb.* p. 706 (No. 2119); Massee in *J. linn. Soc. (Bot.)*, XXXV, 99.
   Mollisia peristomialis Phill. *Brit. Discom.* p. 201.
   Cyathicula peristomialis Sacc. *Syll. F.* VIII, 308 (No. 1284); Massee, *Brit. F. Fl.* IV, 273 ("*peristomalis*").

   This very curious species was the only member of the subgenus *Peristomialis* of *Mollisia* in Phillips's *Brit. Discom.*, and Boudier later established the genus *Peristomialis*, changing the specific name of the species into *P. Berkeleyi*. The taxonomic position of the genus was discussed by v. Höhnel (M. Fr. p. clviii), and he suggested from the description and the illustrations that it might belong to the "Nectriaceae". When studying the type specimen I recognised at once that v. Höhnel had been right in excluding the genus from the Discomycetes and that, in reality, it is identical with *Ijuhya* Starb. V. Höhnel has given several good descriptions of this hitherto monotypic genus (*Denkschr. Akad. Wiss. Wien*, LXXXIII, 22; Fr. z. M. pp. 691 and 762). I cannot for the present decide whether *Peziza peristomialis* is identical

with *Ijuhya vitrea* Starb., known from Brazil and Java, or specifically distinct from it.

38. **Phaeangium phaeosporum** (Cke.) Sacc. & Syd. ap. Sacc. *Syll. F.* XVI, 765; Boud. *Discom. d'Eur.* p. 162.

   Cenangium phaeosporum Cke. in *Grev.* XII, 44; Phill. *Brit. Discom.* p. 346; Sacc. *Syll. F.* VIII, 570 (No. 2354).
   Schweinitzia phaeospora Massee, *Brit. F. Fl.* IV, 135.

   The type specimen in Herb. Kew. is poor and in a very bad condition. No character could be detected that would distinguish it from *Velutaria rufo-olivacea* (A. & S. ex Fr.) Fuck. except the more uniform darker colours, which are certainly due to bad preservation. Thus both the original species of *Schweinitzia* Massee (non Elliot) are *Velutaria rufo-olivacea* and Massee's genus becomes synonymous with *Velutaria* Fuck. (see Nannfeldt, 1932, p. 302).

   Saccardo & Sydow placed *Cenangium phaeosporum* in the genus *Phaeangium* (Sacc.) Sacc. & Syd. (non Pat.). The first species of that genus, *P. Rubi* (Bäuml.) Sacc. & Syd., is most probably a synonym for *Pezicula Rubi* (Lib.) Niessl (see Nannfeldt, 1932, p. 92), and the sixth and last of the original species, *Phaeangium patellatum* (Cke.) Sacc. & Syd. (= *Cenangium patellatum* Cke.), described from U.S.A. as growing on branches of *Acer*, is, according to the type specimen (at Kew), *Dermatea Cerasi* Fr. on *Prunus*. It seems most probable that the remaining species of *Phaeangium* Sacc. & Syd. are stages of well-known species with spores coloured because of age or bad preservation.

   The genus *Phaeangella* (Sacc.) Massee seems to be in a similar position. Two species described by Hazslinsky as *Cenangium quercinum* (on oak) and *Tympanis Potentillae* (on *Potentilla fruticosa*) and later transferred to *Phaeangella* are both according to authentic material at Kew *Dermatea Cerasi* Fr. (on *Prunus*!). It is almost incredible how careless mycologists have been in describing "new" species and in naming their host plants. *Phaeangella Prunastri* (Fr.) Massee and *P. Morthieri* (Fuck.) Sacc. & Syd. are also species of *Dermatea*.

39. **Pithyella hydnicola** (B. & Br.) Boud. *Discom. d'Eur.* p. 125.

   Peziza (Mollisia) hydnicola B. & Br. in *Ann. Mag. nat. Hist.* (4), VII, 434 (No. 1327).
   Mollisia (Mollisiella) hydnicola Phill. *Brit. Discom.* p. 194.
   Pseudohelotium (Mollisiella) hydnicola Sacc. *Syll. F.* VIII, 304 (No. 1269) ("*hydnicolum*").
   Mollisiella hydnicola Massee, *Brit. F. Fl.* IV, 223.

   This species, which has remained very doubtful and known only from the very short original description, is represented in Broome's

herbarium (at Brit. Mus.) by part of the type gathering. Very super-ficial inspection showed that it did not grow *on* a *Hydnum*, but *through* a resupinate *Hydnum*. Its substratum is some kind of frondiferous wood, most probably oak. The fungus is typical *Corynella atrovirens* (Pers.) Boud. The spore description by Berkeley & Broome is totally false. They probably never saw the spores but mistook large drops of oil or protoplasm for them.

40. **Pseudopeziza foecunda** (Phill.) Massee, *Brit. F. Fl.* IV, 200; Boud. *Discom. d'Eur.* p. 180.

> *Peziza (Mollisia) foecunda* Phill. ap. Stevenson, *Mycol. Scot.* p. 326.
> *Mollisia foecunda* Phill. *Brit. Discom.* p. 189.
> *Pyrenopeziza foecunda* Sacc. *Syll. F.* VIII, 369 (No. 1523).

This species, which was distributed in Phill. *Elv. brit.* No. 184, is identical with *Hysteropezizella subsessilis* (Rehm) Nannf. (see Nann-feldt, 1932, p. 121, where the full synonymy is to be found). The sub-stratum given as "*Eleocharis*", is *Scirpus caespitosus*. As Phillips's name antedates the other names the fungus should be known as *Hystero-pezizella foecunda* (Phill.) Nannf. n.comb.

Mollisia scirpina Peck (on *Scirpus caespitosus*) is certainly identical, but I know it only from the description.

41. **Pyrenopeziza cyanites** (Cke. & Phill.) Boud. *Discom. d'Eur.* p. 133.

> *Mollisia cyanites* Cke. & Phill. ap. Phill. *Brit. Discom.* p. 176; Sacc. *Syll. F.* VIII, 351 (No. 1452).
> *Belonidium cyanites* Massee, *Brit. F. Fl.* IV, 225.

The type specimen of this species (at Kew) is very poor. The sub-stratum was originally given as "some herbaceous stem". I was therefore very surprised to recognise it as *Phragmites communis*. The fungus was so sparse that I had to refrain from making a micro-scopical study. The macroscopical features and Massee's very full description indicate *Tapesia Kneifii* (Wallr.) v. Höhn. (= *T. retincola* (Rabenh.) Karst.) (see v. Höhnel, Fr. z. M. p. 1223). It is most unfortunate that mycologists so often describe "new" species on such insufficient material and that they take so little care in naming the host plants!

Mollisia mediella Karst. may be the same species. The superficial Mollisioid Discomycetes on *Phragmites* are greatly in need of a critical revision. Cultural experiments are needed to show to what extent the development of a dark subiculum depends upon external con-ditions.

42. **Pyrenopeziza grisella** (Cke. & Phill.) Boud. *Discom. d'Eur.* p. 134.
    Peziza grisea Carm. in sched.
    Lachnella grisella Cke. & Phill. ap. Phill. *Brit. Discom.* p. 260.
    Trichopeziza grisella Sacc. *Syll. F.* VIII, 413 (No. 1702).
    Dasyscypha Carmichaeli Massee, *Brit. F. Fl.* IV, 363.

This species, according to the type specimen at Kew, belongs to *Unguicularia*. The hairs and the hymenium, etc., are exactly those of *U. scrupulosa* (Karst.) v. Höhn., but the apothecia are slightly larger than usual and the excipulum is remarkably dark, which may be due to age. We may safely regard the two species as synonymous. Karsten's specific epithet is the valid one.

43. **Scleroderris majuscula** Cke. & Massee, in *Grev.* XXI, 73; Massee, *Brit. F. Fl.* p. 125; Sacc. *Syll. F.* XI, 425 (No. 2652); Boud. *Discom. d'Eur.* p. 164.

The type specimen (at Kew) is very poor, consisting of a single, detached apothecium. It is *Coryne sarcoides* (Jacq. ex Fr.) Chev.

44. **Tapesia Johnstoni** (Berk.) Phill. *Brit. Discom.* p. 282; Sacc. *Syll. F.* VIII, 381 (No. 1570); Boud. *Discom. d'Eur.* p. 140.
    Peziza Johnstoni Berk. in *Ann. Mag. nat. Hist.* (1), XIII, 17 (No. 313); Berk. *Outl.* p. 369; Cke. *Handb.* p. 695 (No. 2075); Massee in *J. linn. Soc. (Bot.),* XXXI, 515.

After examining the type material of *Peziza Johnstoni*, Massee (*loc. cit.*) identified it with *Tapesia fusca* (Pers. ex Fr.) Fuck. I was very surprised when I saw the material at Kew to find that Massee had been totally wrong, for *Peziza Johnstoni* is identical with the fungus known as *Cenangella radulicola* (Fuck.) Rehm (= *Cenangium radulicola* Fuck. = *Dermatea radulicola* Fuck.) growing, as always, on branches of birch infested with *Eutypa aterrima* (Fr.) v. Höhn. (= *Radulum aterrimum* Fr.). Berkeley's name antedates Fuckel's.

As I have not yet found appropriate material in quantity I have not been able to study the species in detail and cannot decide its taxonomic position.

45. **Trichoscypha calycina** var. **Trevelyani** (Cke.) Boud. *Discom. d'Eur.* p. 125 ("Trevyliani").
    Peziza calycina var. *Trevelyani* Cke. in *Grev.* III, 121.
    Lachnella calycina var. *Trevelyani* Phill. *Brit. Discom.* p. 242.
    Dasyscypha calycina var. *Trevelyani* Sacc. *Syll. F.* VIII, 438 (sub No. 1822); Massee, *Brit. F. Fl.* IV, 342.

The type specimen of this variety is *Trichoscyphella Willkommii* (Hart.) Nannf. (= *Dasyscypha Willkommii* (Hart.)). I could not find any spores larger than $24 \times 8 \mu$, and the average size was $20 \times 7 \mu$,

just as in typical *Trichoscyphella Willkommii*. The larger measurements given by Cooke must be due to some mistake.

46. **Trichopeziza dematiicola** (B. & Br.) Sacc. *Syll. F.* VIII, 414 (No. 1707); Boud. *Discom. d'Eur.* p. 131.
    Peziza (Mollisia) dematiicola B. & Br. in *Ann. Mag. nat. Hist.* (3), xv, p. 446 (No. 1070); Cke. *Handb.* p. 705 (No. 2117).
    Lachnella dematiicola Phill. *Brit. Discom.* p. 265.
    Dasyscypha dematiicola Massee, *Brit. F. Fl.* IV, p. 364 (saltem p.p.).
    Dasyscypha dematiicola v. Höhn. in *S.B. Akad. Wiss. Wien*, CXVIII, Abt. 1, p. 884.

The type specimen (at Kew) was studied by v. Höhnel (Fr. z. M. p. 339), who identified it with his *Dasyscypha Heimerlii* v. Höhn. I have studied the type at Brit. Mus. and can only assert that it matches v. Höhnel's description of *D. Heimerlii* in all respects.

The systematic position of this species is somewhat obscure. The texture of the excipulum and the characteristic pointed hairs would place it in *Hyaloscypha* Boud. emend. Nannf. but the brown colour of the excipulum (the hairs and the margin excepted) distinguish it from the known species of that genus. Nevertheless, I think it best for the present to call it *Hyaloscypha dematiicola* (B. & Br.) Nannf. n.comb. (see Nannfeldt, 1932, p. 272).

47. **Trochila Buxi** Capron ap. Cke. *Handb.* p. 768 (No. 2315); Phill. *Brit. Discom.* p. 397; Sacc. *Syll. F.* VIII, 729 (No. 2991); Massee, *Brit. F. Fl.* IV, 61; Boud. *Discom. d'Eur.* p. 166.

The type specimen (Herb. Kew.) as well as two additional British specimens (Forden, leg. Vize, and Bungay, leg. Stock) are all *Hyponectria Buxi* (DC.) Sacc. A very full description of this species was given by Petrak (*Ann. mycol.* XXI, 303–6), who also discusses its taxonomic position. It may be noted that *Laestadia Buxi* (Fuck.) Sacc. is the same species (v. Höhn., M. Fr. p. cci), as is also the fungus that Feltgen reported as *Trochila Buxi* Capron (v. Höhnel, *S.B. Akad. Wiss. Wien*, CXV, Abt. 1, p. 1263).

48. **Urceolella elaphines** (B. & Br.) Boud. *Discom. d'Eur.* p. 129.
    Peziza elaphines B. & Br. in *Ann. Mag. nat. Hist.* (4), VII, 434 (No. 1325); Massee in *J. linn. Soc. (Bot.)*, XXXV, 90.
    Mollisia elaphines Gill. *Champ. Franc. Discom.* p. 131; Phill. *Brit. Discom.* p. 179.
    Pseudohelotium elaphines Sacc. *Syll. F.* VIII, 301 (No. 1257).
    Dasyscypha elaphines Massee, *Brit. F. Fl.* IV, 366.

The identity of *Peziza elaphines* B. & Br. and *Peziza scrupulosa* Karst. (= *Unguicularia scrupulosa* (Karst.) v. Höhn.) was demonstrated by

v. Höhnel (*Mitt. Bot. Inst. Techn. Hochsch. Wien*, v). I can only confirm v. Höhnel's statement.

49. **Urceolella leuconica** (Cke.) Boud. *Discom. d'Eur.* p. 130.

  Peziza leuconica Cke. in sched.
  Lachnella leuconica Phill. *Brit. Discom.* p. 267.
  Trichopeziza leuconica Sacc. *Syll. F.* VIII, 414 (No. 1709).
  Dasyscypha leuconica Massee, *Brit. F. Fl.* IV, 334.

The type specimen (at Kew) shows that it belongs to the genus *Hyaloscypha* Boud. emend. Nannf. (Nannfeldt, 1932, pp. 272–3.). The substrate is coniferous wood, probably pine. It is distinct from all species known to me by the much longer hairs. As closely allied forms are described in *Trichopeziza*, *Lachnella*, *Dasyscypha*, *Pezizella*, and many other genera, it is impossible for the present to form a definite opinion as to the validity of the specific epithet, but the species may *ad interim* be designated as *Hyaloscypha leuconica* (Cke.) Nannf. n.comb.

50. **Urceolella Stevensonii** (B. & Br.) Boud. *Discom. d'Eur.* p. 130 ("*Stephensoni*").

  Peziza (Mollisia) Stevensoni B. & Br. in *Ann. Mag. nat. Hist.* (4), xv, 38 (No. 1485).
  Lachnella Stevensoni Phill. *Brit. Discom.* p. 235.
  Dasyscypha Stevensoni Sacc. *Syll. F.* VIII, 454 (No. 1889); Massee, *Brit. F. Fl.* IV, 364; Boud. *Discom. d'Eur.* p. 122.

Quite twenty years ago v. Höhnel (M. Fr. p. x) described *Dasyscypha resinifera* v. Höhn., a species said to grow on old, prostrate, still hard coniferous logs, and to be very common in Lower Austria, and also to occur in Germany and Sweden. I was later able to show (Nannfeldt, 1932, p. 273) that this most characteristic species was identical with *Pezizella atomaria* Starb. and belonged to *Hyaloscypha* Boud. emend. Nannf. During my stay in England I found that the fungus was described still earlier by Berkeley & Broome as *Peziza Stevensoni*, and that the substratum of the type material was pinewood. The valid name of this species therefore becomes *Hyaloscypha Stevensoni* (B. & Br.) Nannf. n.comb.

A specimen in Broome's herbarium (Brit. Mus.) is by a slip of the pen labelled *Peziza Andersoni*, and the collector's name given as J. Anderson.

A LEAF-SPOT DISEASE OF SWEET WILLIAM CAUSED BY *HETEROSPORIUM ECHINULATUM*

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(With 3 Text-figures)

INTRODUCTION

THE diseased Sweet William plants (*Dianthus barbatus* L.) which were utilised in the present investigation were sent to the Plant Pathological Laboratory of the Department of Agriculture for Scotland in May 1932.

The leaves of the plants were heavily infected, bearing numerous brownish patches covered with olive-green conidia. The fungus was identified as *Heterosporium echinulatum* (Berk.) Cooke, and it was associated with some small black bodies on several of the over-wintered leaves. On examination a few of these bodies were found to contain mature asci, so, in view of the fact that no perfect stage of *Heterosporium echinulatum* has yet been recorded, the present investigation was undertaken primarily in order to ascertain whether these perithecia represented the perfect stage in the life history of this fungus. In the course of the work, however, certain other observations were made which have also been included in the present paper.

HISTORICAL

The fungus was first described and named in 1870 by Berkeley in an illustrated account of a new disease on carnation leaves. He placed the causal fungus in the genus *Helminthosporium* as a new species *H. echinulatum*.

In 1873 Berkeley & Broome published a description of a disease on Sweet William caused by another new species of *Helminthosporium*, *H. exasperatum*. Four years later Cooke transferred *H. echinulatum* to the genus *Heterosporium*, and cited *Helminthosporium exasperatum* as a synonym.

In 1881 Saccardo and Roumeguère described a fungus on *Dianthus barbatus* and named it *Heterosporium Dianthi*, but this name, together with *H. exasperatum*, was later cited by Saccardo (10) as a synonym of *H. echinulatum*.

In most references to the disease the parasite appears to have been confined to the leaves and stems of the hosts, but in 1890 Lindemuth

referred to a case where the mycelium spread to the sepals and prevented the opening of the flowers.

No mention is made of sclerotia in any of the earlier references to the disease, but in 1906 Cooke stated that numerous minute sclerotia are said to be formed in the dying leaves. Massee (8) also mentioned sclerotia, and recorded that they remain in a passive condition until the following season when they produce minute conidia. From this paucity of references to sclerotia in early records of the fungus it would seem that they are not of frequent occurrence.

<div align="center">CULTURAL STUDIES</div>

Ascospores were removed from crushed perithecia and placed in hanging drops of sterile water in a moist chamber. They germinated in less than twenty-four hours, each cell giving rise to a germ tube which grew rapidly and produced a branching mycelium in two to three days. In five to six days conidiophores developed which cut off typical *Heterosporium echinulatum* conidia, thus establishing the relation between the perfect and imperfect stage of this fungus. Single ascospores planted on malt extract agar gave rise to a somewhat dome-shaped mass of mycelium, white above and olive green underneath, which produced typical *H. echinulatum* conidia in four to five weeks when the colony was about 1–1¼ in. long.

Single conidia were also isolated from the original material and were found to give rise to two distinct types of culture on malt agar. One (type A) was exactly similar to that derived from single ascospores, the other (type B) differed in the time that elapsed before the formation of conidia, which here was only four to ten days. When conidia were produced the surface colour of the culture changed, becoming greyish green in type A and olive green in type B. This difference in colour appeared to be due to the development of large numbers of conidia on a small culture in type B whereas they were more scattered in type A. Conidia from these two types were repeatedly reisolated and transplanted but the distinction persisted on malt agar. If, however, sterilised carnation and Sweet William leaves were utilised instead of an agar medium, conidia were produced freely by both A and B types after ten to twelve days.

There appeared to be a great deal of variation in size between conidia from different cultures on the same medium and also between those on different media. Conidia from sterilised carnation leaf cultures, which were subcultures of the original malt agar cultures, were markedly larger than those of the parent cultures, and conidia from these leaf cultures put back on malt agar produced a mycelium which also gave rise to large conidia (Table I).

In all the malt agar cultures, whether derived from conidia or

Table I. *Measurements of conidia (in μ)*

Source of conidia	Range	Mean
Original material	16–52 × 8–14	31·71 × 10·81
Malt agar culture (A type) old	18–55 × 8–13	30·3 × 10·47
,, (B type) ,,	18–51 × 8–14	30·86 × 10·86
,, (A type) young	16–45 × 7–13	27·53 × 10·09
,, (B type) ,,	20–50 × 6–13	31·66 × 9·5
Sterilised carnation leaf culture	26–54 × 9–14	38·42 × 11·01
Subculture from carnation leaf on malt agar, 6 days old	29–53 × 9–14	39·93 × 12·37

ascospores, dark knotted masses of hyphae appeared after about five weeks. These were thought to be young perithecia, but they did not develop further although the cultures were kept for six months. On sterilised carnation and Sweet William leaves immature perithecia developed after twelve to fifteen days, the majority of them being formed on the surface furthest from the point of inoculation. They were most abundant towards the base of the tube where there was a greater percentage of water, and they developed particularly at points where the leaf was in contact with the glass. Perithecia in fifteen days old cultures measured from 60 to 116 μ in diameter, were black, roughly spherical, but differed from those of the original material in having a large number of black hyphae projecting from the walls. A short typical beak was present and the apical cells of the beak were colourless. On crushing them no asci were seen, and the contents were found to consist of a ball of hyaline cells and numerous oil globules.

In an attempt to obtain mature perithecia some conidia were planted on sterilised Sweet William leaves on December 6, 1932, and kept in the laboratory until January 10, 1933, when two of them were placed in an unheated greenhouse. Perithecia were taken from all the cultures and examined every fortnight, and asci were found in the greenhouse cultures in May 1933. The percentage of perithecia containing asci was small, as in the original material, and many of the asci were degenerate, but a few contained fully developed ascospores which agreed in every respect with those found on the original material. None of the perithecia in cultures kept in the laboratory developed asci, but the perithecia in seven to eight months old cultures which were kept damp grew very irregular in shape and the beak often became elongated (Fig. 1 b). In cultures which were allowed to dry the perithecia remained spherical and exactly resembled those of the original material.

DESCRIPTION OF FUNGUS

The conidial stage has been frequently described (1, 2, 3, 8), and it is therefore proposed to proceed at once to the description of the perfect stage.

The perithecia were black and irregularly spherical, 100–270 μ in diameter, and possessed short stout beaks 10–30 μ high (Fig. 1 *a*). The outer part of the walls consisted of two to three layers of dark brown cells, and the inner part of a few layers of colourless cells.

Fig. 1. *Didymellina Dianthi*. A, typical perithecium on original diseased material; B, abnormal perithecium from culture on Sweet William leaf. Perithecia × 400.
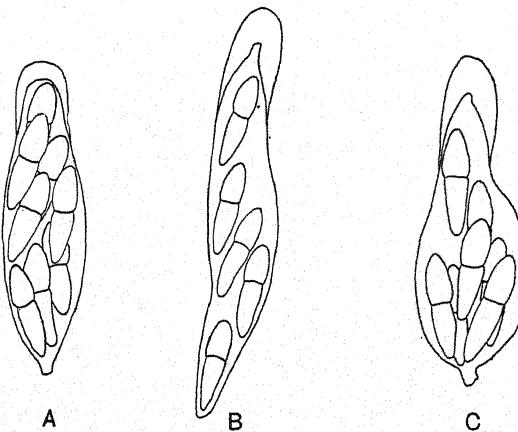
Fig. 2. *Didymellina Dianthi*. Asci from Sweet William leaf culture. A, typical ascus from centre of perithecium; B, abnormally elongated ascus; C, ascus from side of perithecium. (× 500.)

The percentage of perithecia containing asci was small, about 10 per cent., and the remainder appeared to be sterile. When kept under moist conditions, however, many of the sterile perithecia developed tufts of conidiophores from the beak, the conidia exactly

resembling those of *Heterosporium echinulatum*. None of the fertile peri-
thecia examined were producing conidia, so it would appear that
sterile perithecia may function as sclerotia. This resembles the be-
haviour reported by Tisdale in the related species *H. gracile* (11).

The number of asci in a fertile perithecium varied from eight to
eighteen according to the size of the perithecium. They were fascicled
and attached by short pedicels to a mass of pseudoparenchyma in
the base of the perithecium. Paraphyses were absent. The asci were
thin-walled, hyaline and very irregular in shape. As the bundle of
asci fitted exactly into the cavity of the perithecium, those towards
the outside were shorter, stouter and club-shaped (Fig. 2 *c*), whereas
those in the centre tended to be elongated and spindle-shaped (Fig.
2 *a*, *b*). The wall was thickened at the apex up to 10μ, and occa-
sionally the cavity of the ascus was extended upwards into the centre
of this thickening (Fig. 2 *b*, *c*).

Most of the asci contained eight ascospores lying parallel or slightly
oblique to the long axis of the ascus. The ascospores measured
$22-31 \times 7-9\mu$, and were torpedo-shaped, two-celled, thin-walled and
colourless, the upper cell being $1-6\mu$ (average $3\cdot3\mu$) shorter, and
slightly wider than the basal cell. The spores were somewhat con-
stricted at the septum.

INFECTION EXPERIMENTS

Infection experiments were carried out with pot plants of Sweet
William, carnations and pinks. A suspension of conidia was injected
into the leaves with a hypodermic syringe; the control plants were
similarly treated, sterile water being used instead of the suspension.
The conidia for some inoculations were obtained from monoascospore
cultures, for others from type A or B cultures derived from single
conidia off the original material. Ascospores were not utilised for
these experiments owing to the scarcity of mature asci. The plants
were kept under bell jars in the laboratory for forty-eight hours after
inoculation and then placed in an unheated greenhouse and watered
from below.

All the Sweet William plants developed lesions around the point
of inoculation. These consisted of yellowish brown withered patches
with a purplish margin (Fig. 3); they appeared in six to ten days and
attained a diameter of about half an inch after four weeks. Very few
conidia were found on these patches, so, since extremely dry condi-
tions were prevalent in the greenhouse, an infected leaf was removed
and placed on moist filter paper in a sterile Petri dish. Numerous
hyphae developed within twenty-four hours on both sides of the
infected area, and it was green with conidia forty-eight hours after
removal to moist conditions. One of the infected plants was then
placed under a bell jar, and it developed numerous conidia on the

infected areas after forty-eight hours. Conidia from these leaves were isolated on malt agar slopes and gave rise to typical cultures. The uninfected leaves of the plants remained healthy and the plants flowered.

Two months after inoculation the diseased areas had extended over the greater part of the infected leaves, but the plants were otherwise healthy. The control plants remained healthy and the injured points healed leaving only a small yellow scar.
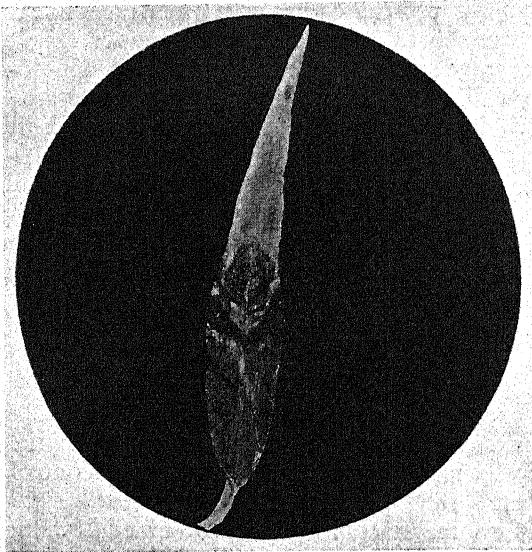
Fig. 3. Sweet William leaf artificially injected with *Heterosporium echinulatum* photographed two months after inoculation. The upper half of the leaf has been killed and the diseased area is delimited by a dark purple margin. About two-thirds natural size.

The injected carnations and pinks, on the other hand, showed only a very slight reaction, consisting of a yellowish area with a definite purple margin which, after four weeks, extended about $\frac{1}{8}$ in. around the point of inoculation. No *Heterosporium* conidia were found on the infected leaves, but in one or two sections hyphae were found on the injured part of the epidermis apparently growing saprophytically. Two leaves of pink and two of carnation were therefore cut off and kept moist in sterile Petri dishes. In two days hyphae developed on both of the pink leaves and on one of the carnation leaves, and conidia appeared in three days. These were *Cladosporium* on both pink leaves and on one of the carnations, but on the other carnation a few *Heterosporium echinulatum* conidia were also found. The mycelium,

however, did not spread to the uninjured part of the leaf which remained free from hyphae.

The wound made by the needle on the controls healed, leaving a small yellow withered piece of epidermis, but no extension of the necrotic area was observed and no purple discoloration developed.

Table II. *Infection experiments*

Host	No. of plants	Total no. of leaves inoculated	Result Diseased	Result Healthy	No. of control plants	No. of leaves injected	Result Diseased	Result Healthy
Sweet William	3	22	20	2	1	6	0	6
Carnation	6	36	32*	4	1	6	0	6
Pink	3	24	20*	4	1	6	0	6

* Slightly discoloured.

The results of the infection experiments are summarised in Table II. These inoculations were all carried out in early summer, but a subsequent series made on Sweet William in the autumn showed that infection did not take place so readily at that season, neither did the lesions attain so great a size.

It is evident that the strain of *Heterosporium echinulatum* utilised in the present investigation is actively parasitic on Sweet William but has little effect on carnations and pinks. The two last-named plants, however, are well known as hosts of this fungus, a fact which leads to the conclusion that there must be two or more specialised races of the fungus upon the different host plants.

DISCUSSION

There appears to be no previous record of the perfect stage of *Heterosporium echinulatum*, nor could I find a description of any perithecial form on Sweet William, carnation or pink which corresponds to the perithecial stage described in the present paper. Tisdale (11) and Klebahn (6) have both published accounts of the perfect stage of *H. gracile*, the former identifying it as *Didymellina Iridis* (Desm.) v. H., while the latter regarded it as a new species which he named *D. macrospora*. The genus *Didymellina* was established by von Höhnel (5), but no adequate generic description was published. This fact somewhat complicates the identification of the perfect stage of *Heterosporium echinulatum*, but as the fungus agrees in essential points with the species described by Tisdale, it is thought advisable to use the name *Didymellina* for the perithecial form described in the foregoing pages. The specific epithet *echinulatum* refers to a character of the conidium wall which is by no means always well marked and which, in any case, is not applicable to the ascospores. The name *Didymellina*

Dianthi is therefore proposed for the new perfect stage of the fungus, since it occurs only, so far as we know, upon certain species of *Dianthus*.

Didymellina Dianthi n.sp.

Perithecia suberumpentia, atrobrunnea vel nigra, laxe gregaria, irregulariter sphaerica, 100–270 μ diametro, rostro brevi 10–30 μ longo. Asci in perithecio 8–18-nati, fasciculati, breviter pedicellati, quoad formam atque magnitudinem valde variabiles, muro hyalino infra tenui apicem versus ad 10 μ crasso, sporis octonis; paraphyses desunt. Ascosporae hyalinae, ovali-ellipticae, 22–31 × 7–9 μ, uniseptatae, ad septum paulo constrictae, cellula superiore paululo breviore atque latiore quam inferiore.

Hab. in foliis *Dianthi barbati* tempore hiberno emarcidis. Apud hortos nonnullos in Scotia.

Forma conidialis—*Heterosporium echinulatum* (Berk.) Cooke.

SUMMARY

1. The perfect stage of *Heterosporium echinulatum* was found on some over-wintered leaves of diseased Sweet William plants, and was subsequently obtained in culture on sterilised Sweet William leaves. The relation between the two stages was proved by monospore cultures.

2. Only a small percentage of the perithecia matured; the remainder developed tufts of conidiophores from the beak if kept under moist conditions.

3. Infection experiments indicated the probability of specialised races of the fungus on different hosts, for Sweet William plants were very susceptible while carnations and pinks proved highly resistant.

4. The name *Didymellina Dianthi* is proposed for the new perfect stage, a diagnosis of which is given.

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CORDYCEPS MILITARIS AND ISARIA FARINOSA

By T. PETCH

In *Ann. Sci. nat.* Ser. 3, xx (1853), 43, Tulasne stated that he had reason to believe that the conidial stages of *Cordyceps militaris, C. entomorrhiza*, etc., were included in the genus *Isaria* as autonomous fungi. Subsequently, in the same journal, Ser. 4, viii (1857), 35–43, he published the results of experiments which, he considered, proved that *Isaria farinosa* was the conidial stage of *Cordyceps militaris*. Figures in support of that conclusion were given in *Selecta Fungorum Carpologia*, iii (1865), Pl. I.

Tulasne obtained a number of dead or dying larvae of *Bombyx rubi*, the victims of a breeding experiment, and placed them on damp sand. They developed a white covering of mycelium, from which arose erect conidiophores, with whorls of branches, each terminated by a chain of conidia. He germinated these conidia in a hanging drop, and found that they reproduced the same conidiophores and conidia. Evidently that was the simple *Spicaria* form of *Isaria farinosa*, though Tulasne described the conidia as spherical, $1 \cdot 5 \mu$ diameter, and rather confused matters by a reference to *Botrytis Bassiana*. His figures, however, show that he was not dealing with the latter species, and his description of the spores as spherical was perhaps due to the inadequacy of his lenses.

The byssoid covering soon became orange-yellow here and there, and developed *Isaria farinosa*. There is little doubt that Tulasne's identification of that was correct. Subsequently, many of the *Isaria* clavae were attacked by *Melanospora parasitica*.

The experiment was begun in the middle of March. At the beginning of June, some of the larvae, which had produced only a few *Isaria* clavae, or none at all, their segments having remained only more or less whitened by the conidiiferous mycelium, began to develop *Cordyceps militaris*, which matured at the beginning of July. Some of these *Cordyceps* clavae bore conidiophores towards the base.

In *Selecta Fungorum Carpologia*, iii (1865), 6, Tulasne gave further details. He said that the conidiophores and conidia were the same, whether they occurred on the mycelium or on the *Isaria* clavae, and that they were very often to be found also on the "roots" or lowest parts of the *Cordyceps* clava. On germination of the ascospores (partspores) of the *Cordyceps*, hyphae were produced, from which arose branches bearing chains of conidia or even whorls of chains of conidia.

The conidia produced from the ascospores were exactly similar to those of *Isaria farinosa*.

Tulasne's figures, Pl. I, figs. 19 and 20, show larvae bearing *Isaria farinosa* only. Figs. 21, 22, 23 show germinating conidia of *I. farinosa*, producing whorls of phialides bearing apical chains of conidia, evidently a regular *Spicaria*. Figs. 24, 25, 26 show larvae bearing *Cordyceps militaris* only, not accompanied by *Isaria farinosa*. Fig. 27 is that of the mycelium and conidiophores found at the base of a *Cordyceps* clava, and it shows one, two, or three phialides on the apex of a hypha and others below, but the latter are scattered, not in whorls; only one conidium is present at the apex of a phialide, but the absence of chains might be attributable to loss in manipulation. Fig. 28 is a view of the perithecial clava enlarged. Figs. 29 and 30 show germinating part-spores, and Fig. 31 shows a resultant hypha with conidiophores; the phialides are scattered along the hypha, or three occur on the apex of a short lateral branch; they bear chains of conidia, except in one case where three conidia are shown side by side at the apex of a phialide.

Judging these figures in the light of recent cultures of *Isaria farinosa* and of the ascospores of *Cordyceps militaris*, which will be described later in this paper, it is clear that while Figs. 27 and 31 represent, somewhat imperfectly, the conidial stage of *C. militaris*, they are not figures of *Isaria farinosa*. The fungus shown is not the regular *Spicaria* of *Isaria farinosa*. Other differences will be enumerated in the following pages.

Evidently, as might be expected, Tulasne's material contained a mixture of fungi. Some of the larvae were infected by *Isaria farinosa*, and these produced, first a white mycelium which bore simple *Spicaria* conidiophores, and later the clavae, of *Isaria (Spicaria) farinosa*. Others were infected with *Cordyceps militaris*, and, as the conidial stage of that fungus is not luxuriant in nature, they bore only a slight covering of conidiiferous mycelium, and ultimately produced *Cordyceps* clavae.

It may be mentioned that, from a collection of pupae of the Cinnabar moth, which had died during a breeding experiment at Farnham Royal, I obtained *Isaria farinosa*, *Beauveria Bassiana*, *Monilia penicillioides*, *Gymnoascus Reesii*, and undetermined species of *Fusarium* and *Stilbella*.

Tulasne's theory met with considerable opposition. De Bary, after carrying out experiments on the subject, at first rejected it, but subsequently accepted it. The following details, taken from de Bary's *Vergleichende Morphologie und Biologie der Pilze*, etc. (1884), give the reason for his change of opinion.

"In [*Bot. Zeitung*, 1869] and 1867, I had expressed doubts concerning the view maintained by Tulasne that *Isaria farinosa* belonged to the cycle of development of *C. militaris*, basing those doubts partly

on the failure to obtain perithecial clavae and *Isaria* forms reciprocally from one another in culture, and partly on differences, certainly only quantitative, in the branching of the conidiophore. The latter objection might easily be dismissed, and, as already remarked in the foregoing text, I now believe that the former cannot be maintained. A caterpillar of *Sphinx euphorbiae*, which had been infected with ascospores and had become, as usual, a sclerotium, when laid on moist sand produced first two small perithecial clavae with normal perithecia. These died before the asci were fully developed, and then *Isaria* was produced in abundance. Portions of the mycelium cultivated on microscope slides had previously afforded *Isaria*. In this case, therefore, either *Isaria* was ultimately produced from the ascospores, or the insect had been infected with *Isaria* unintentionally at the same time as with the ascospores, and the *Isaria* had, in its later development, suppressed and supplanted the perithecial form. I have no reason for assuming such an accidental infection, and have accordingly formed the foregoing conclusion. But the possibility of such an admixture is not excluded, and therefore I could not omit to mention it.''

De Bary stated that if the ascospores were sown in water or in a nutrient solution, germination occurred, with branching of the resultant hyphae dependent upon the amount of nutrient present. In water, only short hyphae, with few or no branches, were produced. Some of the branches spread through the nutrient solution as a mycelium; others emerged from the liquid into the air, where they produced whorls of phialides which bore conidia in chains. The first conidium on a phialide was cylindric, like those in the body of the insect, but usually shorter. All the succeeding conidia were globose. The latter could therefore be called globose or aerial conidia. The mycelium which developed in the dead caterpillar very often produced aerial conidia, but no cylindric conidia. The conidiophores which were found on most of the caterpillars which bore perithecial clavae were small, like those described above, and formed a delicate down on the surface. [On the other hand, on other insects they grew into a dense mould-like covering some millimetres in height, or, like the *Coremium* form of *Penicillium*, they formed clavate structures, 1–2 cm. high, with an orange-yellow stalk, covered above with phialides bearing conidia. These last-named bodies were known as a form species under the name of *Isaria farinosa*. Both the *Isaria* form and the mould-covering were usually found alone on the sclerotioid insect, without any perithecial clava.] Only once had he been able to obtain, on a caterpillar which had been infected with ascospores and which pupated after infection, two poorly developed perithecial clavae together with large *Isariae*.

Later in the same account (p. 401) de Bary stated that on insects killed by infection with aerial conidia, perithecial stromata were

never observed, but only a fresh crop of aerial conidia, especially the *Isaria* form.

In the foregoing summary, I have bracketed a section which is obviously a general account of *I. farinosa*, as it occurs in nature, not a series of observations by de Bary from his experiments, and which, as it happens, has no relation to the statements which precede it. Attention may be specially directed to de Bary's statement that the conidiophores which accompanied the *Cordyceps* clavae formed only a delicate down on the surface of the larvae.

De Bary identified as *Isaria farinosa* the conidiophores which he obtained on the germination of the ascospores of *Cordyceps militaris* and those found on caterpillars which bore perithecial clavae of that species. Probably for that reason it is not always clear from his account whether in his infection experiments with "aerial conidia" he made use of conidia obtained by germination of the ascospores or conidia taken from naturally grown specimens of *Isaria farinosa*. For example, in the statement quoted above from p. 401, aerial conidia would appear to mean conidia taken from *I. farinosa*. Nor is it always certain whether his references to "*Isaria*" mean the compound Isarioid form or the individual conidiophores, *e.g.* in his statement that "*Isaria*" developed from mycelium on microscope slides.

It will be noted that de Bary observed differences between the branching of the conidiophores obtained by germination of the ascospores of *Cordyceps militaris* and that of the conidiophores of *Isaria farinosa*, but did not, finally, consider them of importance. Both Tulasne and de Bary appear to have restricted their comparisons to conidiophores obtained by germination of the ascospores of the *Cordyceps* and of the conidia of the *Isaria*, respectively, in their earlier stages in hanging drops. Later, they are quite different. The early conidiophores of the *Isaria* may lack prophialides, and thus resemble to some extent those of the *Cordyceps*, though on the latter, the phialides as a rule are not so regularly arranged in whorls. But the conidiophores which occur on the *Isaria* clava are furnished with whorls of prophialides, each prophialide bearing a cluster of phialides with apical chains of conidia. De Bary's figure, 165 E, as far as regards the branching of the conidiophore, might be matched by the early conidiophores of *I. farinosa* in culture, but the chains of conidia are irregular, and on some of the phialides the conidia are in more or less globose heads, resembling in the latter respect an *Acrostalagmus*.

In 1894, G. F. Atkinson published a paper, "Artificial cultures of an entomogenous fungus," in *Bot. Gaz.* XIX, 129–45, with three plates. From his figures, he was evidently dealing with *Isaria farinosa*, as understood in this country. He did not obtain any perithecial clavae in culture.

In 1895, R. H. Pettit published *Studies in Artificial Cultures of Entomogenous Fungi*, Bull. No. 97, Cornell Univ. Agric. Exp. Sta., Bot. and Ento. Divisions. One of the fungi was *Cordyceps militaris*, cultures of which were made from ascospores (part-spores). The following is taken from Pettit's account:

"Germination from these swollen spore segments takes place by the production of germ tubes at one or two points. These soon become branched....The threads are strongly segmented and the branches are strongly constricted at the base. In some cases a healthy thread suddenly becomes constricted and produces an aborted apex of less than half the diameter of the ordinary thread. The aborted portion is usually curled....In about four days the growth appears above the surface of the agar. A strong white cottony growth appears, forming a colony circular in form. At the end of about six days the conidia appear. Short sterigmata [*i.e.* phialides] are borne near the ends of the long cottony threads. They are irregularly arranged either in an opposite or an alternate manner. They are flask-shaped and slender and sometimes forked. The conidia are nearly spherical and are borne in short chains of three or four at the ends of the sterigmata, or at the end of a long thread. The chains are seldom seen, for they almost invariably collapse, leaving the conidia in balls at the ends of the sterigmata."

Pettit also grew the fungus on potato in tubes. The mycelium on the surface of the potato, and the potato itself, were coloured pale orange or brilliant chrome-yellow, wherever they touched the glass. In a half-litre flask of potato, what was probably the beginning of a perithecial clava, deep reddish orange in colour, was observed at the end of about three months. No *Isaria* forms were obtained.

Pettit's figures show short phialides, narrow flask-shaped, scattered along the hyphae, sometimes opposite, sometimes alternate, sometimes in whorls of three. Two phialides may occur on the apex of a short lateral branch of the main hypha (Pettit's forked sterigma), and a phialide may be produced into a long slender thread. The conidia are shown in short chains, or in a small head at the apex of a phialide.

On comparing these figures with those of Tulasne and de Bary, it is seen that they are essentially the same. De Bary's figure, 165 E, shows apparently a more definite conidiophore, but the phialides are similar, in whorls of three, and the conidia are in heads at the apices of the phialides or in irregular chains. The latter are evidently not the definite chains of a *Spicaria*.

Specimens of *Cordyceps militaris* were collected at Austwick, Yorks., in September 1934. Spore prints were obtained the same night, and

when the specimens were left to dry, the ascospores were extruded in long tendrils which formed fleecy masses over and around the clavae. Cultures were made both from the part-spores in the spore print and from those in the extruded tendrils.

In general, the part-spores germinated readily in hanging drops of water in damp cells. Some of them retained their cylindrical shape. Others assumed an irregular, elongated pentagonal shape, caused by an angular bulging out of one of the longer sides near one end. Some of the part-spores became oval, but these were not observed to germinate.

In the most general method of germination, a short chain of conidia was produced directly from the part-spore, usually from one of the original corners (as seen in profile). Sometimes two chains were produced, sometimes three, from the original corners, or a chain might arise about the middle of the longest side. The first conidium formed was pyriform, with a subacute base, $3 \times 1 \cdot 5 \mu$, but the succeeding conidia were subglobose, $2 \times 1 \cdot 5 \mu$.

Other part-spores produced a stout hypha, about twice the length of the part-spore, from one end, like a prolongation of the original spore, and then tapered into a conical phialide, which produced a chain of conidia at the apex.

In others, a hypha was similarly produced, but ran through the hanging drop for a considerable length, bearing laterally short, scattered, cylindrical phialides, up to 7μ long, each bearing a chain of conidia at the apex.

Part-spores were also sown on oatmeal agar slants in tubes. Growth was vigorous, and soon the slant bore a thick, greyish white covering, loose and woolly internally, but with an even surface. At the upper edge of the slant, the growth was whiter and somewhat floccose. When old, the covering collapsed into a thin film and became cream-coloured. There was no general growth of erect conidiophores over the surface, nor did it become mealy. The reverse became yellow and then orange, especially where in contact with the glass. No *Isaria* forms have developed in these cultures.

Over the surface of the slant there are no definite conidiophores. Phialides are borne laterally on indefinite hyphae which run in and over the mass of mycelium. These may be alternate, or opposite, or clustered in small groups, sometimes in whorls of three or four, not always at a septum. The phialides are narrow flask-shaped or conical, up to 9μ high, $1 \cdot 5 \mu$ diameter below, tapering to the apex. Sometimes a phialide is prolonged into a very fine hypha, up to 50μ or more long.

At the upper edge of the slant, the hyphae more closely resemble conidiophores. They may have a terminal phialide, or a terminal cluster of two or three, with scattered phialides, or whorls of phialides

below. The whorls, however, are often irregular, consisting of about four phialides arising at one level round the hypha, with one or two a short distance above and below. Sometimes a whorl consists of three phialides and a branch, instead of four phialides, as in de Bary, Fig. 165 E, though the branch may be a simple hypha only. There are no prophialides.

The conidia are produced terminally on the phialide. After the formation of the first conidium, it is pushed aside by the growth of its successor. The conidia are strongly mucilaginous, and adhere to one another and to the apex of the phialide, so that a globose head, like that of a *Cephalosporium*, is formed. Alternatively, the conidia may adhere to one another in a single or double chain. In some instances, the mass of conidia arising from one phialide takes the form of a globose head, surmounted by a chain; apparently, in these cases the conidia first formed assumed the chain arrangement, but those formed later grouped themselves round the apex of the phialide.

There is no organic connection between the conidia in a chain, as there is in *Spicaria* and *Penicillium*. They are not truly catenulate, but simply adhere by virtue of their mucilaginous coat. That is very evident when the conidia are mainly oval or subpyriform, as they then adhere to one another with their longer sides in contact, *i.e.* transverse to the direction of production.

The conidia from phialides over the general surface of the slant were chiefly globose, $1\cdot5$–$2\,\mu$ diameter, with some oval, up to $3 \times 2\,\mu$, and a few subpyriform. At the upper edge of the slant they were chiefly oval, or subpyriform with one end acute, $2\cdot5$–$3 \times 1\cdot5$–$2\,\mu$.

De Bary noted that the first conidium produced by a phialide was cylindric, like the cylindric conidia found in the body of the insect but shorter. That phenomenon occurs in culture, but apparently not universally. One would not, however, call this first conidium cylindric. It is rather pyriform, with a truncate base, up to $6\,\mu$ long and $3\,\mu$ diameter. Frequently this large conidium is perched on the top of a globose cluster of conidia (compare de Bary, Fig. 165 E), or at the apex of a chain of conidia. More peculiar is the fact that in the latter case, when the conidia in the chain are oval and stand transverse to the direction of production, the large terminal conidium stands in the direction of production and consequently at right angles to them.

The results detailed above are in agreement with those obtained by Tulasne, de Bary, and Pettit from cultures of the ascospores of *Cordyceps militaris*. They also agree with those obtained by Mr E. W. Mason, of the Imperial Mycological Institute, in unpublished research on the same subject. The conidial stage of *C. militaris* is a Mucedine, with phialides arranged laterally on indefinite hyphae, though towards the ends of the hyphae they may be grouped so as to simulate

a branched conidiophore. The conidia are borne terminally on the phialide and usually adhere in a globose head. The fungus is perhaps best regarded as a *Cephalosporium*. It is certainly not *Spicaria (Isaria) farinosa*, which has regular whorls of prophialides and broader flask-shaped phialides, with truly catenulate conidia.

Tulasne and de Bary were mistaken in identifying the conidial stage of *Cordyceps militaris* with *Isaria farinosa*. In other respects their morphological results agree with those of subsequent workers. The only detail which conflicts with this conclusion is de Bary's experiment in which the perithecial clavae of *Cordyceps militaris* and large Isariae developed from the same pupa. With regard to that there are two possible explanations. The first is that the larva was infected by *Isaria farinosa*, before de Bary infected it with ascospores of the *Cordyceps*. The second is that the conidial stage of *C. militaris* may, under some conditions, assume an Isarioid shape, just as *Isaria farinosa* may occur as a simple *Spicaria* or as an *Isaria*. But as such an Isarioid form has not occurred in culture, nor been found on a pupa in nature, this second explanation would appear improbable.

As noted by Tulasne and de Bary, the conidiophores of *Cordyceps militaris* may occur on the mycelium on the larva or pupa which bears the perithecial clavae. Apparently they are not always present, or rather, I have failed to find them sometimes. Those I have seen are conical phialides, up to 12μ high, $1-1\cdot5\mu$ diameter at the base, tapering to the apex. They are lateral on the hyphae, or two or three are situated at the apex of a short lateral branch. In one instance, a group of three phialides was seen on the apex of a hypha. The conidia adhere in short chains, or in a small cluster, at the apex of a phialide, and are globose, $1\cdot5\mu$ diameter, or oval, $2 \times 1\cdot5\mu$.

During the last five years, I have made numerous cultures of *Isaria farinosa* with the object of ascertaining whether any specific differences could be established between the different forms of that species, or between the examples which occurred on different hosts. Apart from the fact that *Isaria farinosa* has a definite *Spicaria* conidiophore, cultures of it differ in appearance from those of the conidial stage of *Cordyceps militaris*. They are much looser and more woolly at first, and soon become covered with conidiophores and conidia which give them a mealy appearance. Ultimately, on oatmeal agar or similar media, they produce *Isaria* clavae.

Isaria farinosa has been identified on Lepidopterous larvae and pupae, Hymenoptera, Coleoptera, Aphides, Diptera, and Arachnida. On the larger of these it forms conidial clavae, but on the smaller, and sometimes even on the larger, it produces only a covering of conidiophores. Now that its association with *Cordyceps militaris* has been terminated, one has less difficulty in accepting the identity of the fungi on these different hosts. It is evidently an omnivorous

entomogenous fungus which can attack insects of all kinds. On Hymenoptera, it has been named *Coremium Swantonii* A.L.Sm.

SUMMARY

The conidial stage of *Cordyceps militaris* is a *Cephalosporium*, which occurs on the mycelium on the larva or pupa bearing the *Cordyceps*. It has not been known to produce an *Isaria* form in nature or in culture.

Isaria farinosa is a fasciculate *Spicaria*, and may occur as an *Isaria* or as a simple *Spicaria*. Its perithecial stage, if any, is unknown. It has no relation to *Cordyceps militaris*.

Cordyceps militaris attacks the larvae and pupae of Lepidoptera. There are two records of its occurrence on Coleoptera—on the remains of a cockchafer in the wood of Bailly, Aube, France (Briard), and on a cockchafer, Aude, France (Roumeguère)—but these are generally considered to be erroneous.

Isaria farinosa is a general entomophyte, and is known to occur on Lepidoptera, Hymenoptera, Coleoptera, Diptera, Aphides, and Arachnida.

Cordyceps militaris of the United States of America is the same as the European species.

SPORES AND SPORE GERMINATION IN WILD AND CULTIVATED MUSHROOMS (*PSALLIOTA* SPP.)

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(With Plate III and 2 Text-figures)

Hitherto the classification of the various forms of field and cultivated mushrooms has been based on external morphological characters only, and no account has been taken of the number of spores on the basidium. It has been known for some time that the typical wild species of *Psalliota campestris* and *P. arvensis* have four-spored basidia, with occasional exceptional two-spored individual caps. Sachs in 1868 (see English edition, 1882, Fig. 227) figures two-spored basidia of *Agaricus campestris*, and Buller (1909) records finding two-spored individuals in the wild on manured ground in the campus of the University of Manitoba, but he states that "they differed considerably from the wild field mushrooms of England, in that they were more scaly, browner and possessed relatively very shallow gills". Buller's specimens were evidently not typical *Psalliota campestris*, and unfortunately the origin of Sach's specimen is not known. If two-spored forms of typical *P. campestris* occur in the wild they are rare, and are possibly haploid fruiting bodies of the four-spored type.

It has been stated by Buller and others that the cultivated varieties have two-spored basidia. It is true that two-spored basidia predominate, but, on examination, only one out of three cultivated varieties on the market in this country has shown uniformly two-spored basidia; in the others an appreciable percentage of three-spored basidia occur together with a few one- and four-spored. The variable basidia are not evenly distributed over the gills but are found in patches; Pl. III shows two photomicrographs of the young gills of the fuscous (fig. 5) and the white non-fragrant (fig. 4) cultivated varieties. None of the cultivated varieties examined has shown uniformly four-spored basidia as in the wild species.

The three different varieties of cultivated mushrooms examined and tested for spore germination are as follows:

(1) The fuscous variety on the English market; coarse, thick fleshed, with thick bulbous stipe, tough and tasteless when cooked; basidia and spores variable, basidia one- to four-spored (Pl. III, figs. 1, 1 *a*).

(2) The white non-fragrant variety, also on the market, softer in texture, flesh thinner than in (1), closely resembling the wild *P. campestris*; slight but delicate flavour when cooked; basidia and spores variable, basidia one- to five-spored (Pl. III, figs. 2, 2 *a*).

(3) The white fragrant variety, closely resembling *P. campestris* but rather drier and firmer in texture, with a strong smell when fresh; good texture and flavour when cooked; basidia uniformly two-spored.

In an appendix at the end of this paper full technical descriptions of (1) and (2) are given by Miss E. M. Wakefield. Unfortunately the white fragrant variety (3) has been met with only once; it was bought with stipe cut short, and it has not been possible to procure any more perfect specimens. A full technical description of this and other forms met with under cultivation will therefore have to be deferred to a later publication.

Nothing is definitely known as to the origin of these cultivated forms. The Americans believe that the coarse fuscous variety, which they call *P. brunnescens*, originated in this country and was selected presumably from spawn gathered in the wild; but the wild species *P. brunnescens* is not common either in this country or in the States, and there is no record of its being introduced into cultivation.

There are, however, three records of a form very similar to our fuscous variety occurring in the States. Atkinson (1906) obtained material for his investigation on the development of *Agaricus campestris* from cultures grown in a greenhouse of a two-spored variety of *A. campestris* known as "Columbia", sold by the Pure Culture Spawn Co. of Missouri. This variety is figured and closely resembles the fuscous variety described by Miss Wakefield in the appendix. The stipes of mature pilei of "Columbia" as figured by Atkinson are, however, not bulbous. This may only be due to cultural conditions as the immature unexpanded specimens clearly show the typical bulbous stipe.

Atkinson states that he twice found two-spored *Agaricus* closely resembling certain cultivated forms growing spontaneously in the open; on a lawn which had been mulched with horse manure, and on a hill side of a wooded ravine in the campus of Cornell University.

Murrill (1914) found a number of caps of a fuscous *Psalliota* on an old heap of manure in Bronx Park, New York. He described and figured it in *Mycologia* (1914), and gave it the name of *Agaricus campestre hortensis*. His photographs are not quite clear, and his specimens appear to differ slightly from the common fuscous form on our markets. They are, however, not at all unlike.

F. C. Stewart (1929) purchased spawn from an American Spawn Co., alleged to be the "cream white" variety, but all the pilei produced by this spawn were, as he says, "altogether different from the common mushroom", and, judging from his figures and description,

there is no doubt that he was dealing with the fuscous variety common in this country. Stewart sent specimens to Dr Kauffmann who, after careful examination, expressed the opinion that they might belong to *P. brunnescens*, a species described by Peck (1929), and that he knew of no other species to which the specimens approached more closely; and further that this fuscous form should not be considered as a variety of *P. campestris*, *P. arvensis* or *P. subrufescens*. Murrill also thought that his form seemed very near *P. brunnescens*, and states that it is often cultivated but rarely wild. Peck's figures and description, however, differ in several respects from the fuscous form figured and described by Stewart.

There is also nothing definitely known about the origin of the two white cultivated forms, the fragrant and non-fragrant, but they must have originated at some time from wild species.

The two-spored cultivated varieties are not haploid forms of the four-spored species. The young basidia are binucleate, karyogamy occurs in the basidium, followed by two meiotic divisions resulting in four daughter nuclei, which can be seen distinctly in a resting state just as the sterigmata are about to develop. Sass (1928) describes the passage of two nuclei into each spore in the two-spored form he investigated, and Colson (1935) the same for the two-spored form, and one nucleus into each spore in the four-spored. The nuclei divide again once in the young spore.

<div align="center">SPORES</div>

A number of spores of *Psalliota campestris*, *P. arvensis*, and the several varieties of cultivated mushrooms have been stained and examined for nuclei.

The technique is as follows:

A small platinum loopful of egg albumen, such as is used for mounting microtome sections, is placed on a clean grease-free slide, and spores from a dry spore-trace placed in the drop. The drop is then spread about 1 in. along the slide with a clean glass rod, to ensure the film being thin and even. The slide is then allowed to dry partially for twenty-four hours, protected from dust.

Then the slide is fixed in a fixative recommended by Sass (1929):

1 per cent. glacial acetic acid	...	...	40 c.c.
Commercial formaldehyde...	...	...	10 c.c.
95 per cent. alcohol...	...	...	50 c.c.

for twelve to twenty-four hours, rinsed thoroughly in 50 per cent. alcohol and taken down to water. This fixative hardens the film and the spores do not wash off.

The spore walls of *Psalliota* are dark coloured and somewhat thick, more especially in *P. arvensis*. For the decolorisation of the spore walls

a modification of the method recommended by Brunswik (1924) should be used. Brunswik differentiated with Eau de Javelle after staining with Heidenhain's haematoxylin, but it was found that clearer and better preparations resulted if the process is reversed and the spore walls decolorised before mordanting and staining. The preparations should be left in the Eau de Javelle for half to one hour or longer, until the walls are completely decolorised, then washed thoroughly in water, mordanted in 3 per cent. iron alum for three to four hours, stained overnight in 0·5 per cent. haematoxylin and
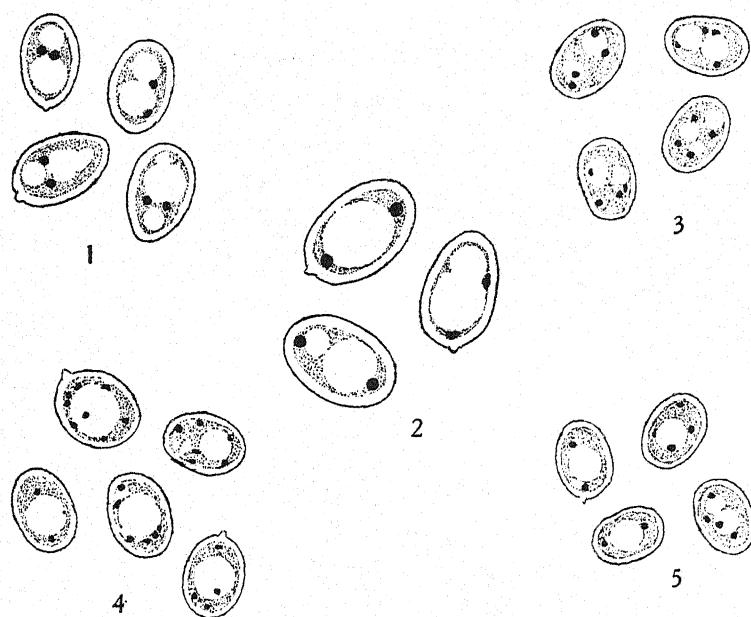
Text-fig. 1. 1, wild *Psalliota campestris*; 2, wild *Psalliota arvensis*; 3, cultivated white fragrant form; 4, cultivated white non-fragrant form; 5, cultivated fuscous form. × 2150.

differentiated in the usual way in 2 per cent. iron alum, until nothing but the colourless spore outlines can be seen under the low power of the microscope. Differentiation requires a little practice, as the nuclei are not visible under a low magnification.

The results obtained from the examination of these spores confirm Sass's observations (1928) on the two-spored form he worked with, and Colson's results recently published (1935), with two- and four-spored forms of *Psalliota*, namely that spores from two-spored basidia are quadri-nucleate (Text-fig. 1 (3)) and those from four-spored basidia binucleate (Text-fig. 1 (1), (2)).

The spores of the fuscous cultivated form with variable basidia (one- to four-spored), showed both binucleate and quadrinucleate spores in the same spore-trace (Text-fig. 1 (5)). The white non-fragrant cultivated form, also with variable basidia, but mainly two-spored, showed spores with from two to eight nuclei (Text-fig. 1 (4)).

Rough counts made in microscope fields taken at random on young gills of the fuscous and non-fragrant white forms are given in Table I.

Table I. *Number of spores on basidia in cultivated forms*

Pileus	Basidia counted	Percentage				
		1-spored	2-spored	3-spored	4-spored	5-spored
		White non-fragrant form				
I	743	4·8	88	6·6	0·5	—
II	359	10	85	5	—	—
Total	1102	6·7	87·2	5·6	0·36	—
		Fuscous form				
I	250	6·8	37·6	48·4	7·2	—
II	250	1·2	49·2	42·8	6·8	—
III	950	3·4	62·6	29·1	4·4	0·3
Total	1450	3·6	56	34·8	5·3	0·2

Spore measurements

Wild species. Basidia four-spored:

    Psalliota arvensis ... ... $8·9–11·1 \times 6·4–7\,\mu$

    P. campestris ... ... $7·6– 8·9 \times 5·1–6·4\,\mu$

Cultivated varieties. Basidia two-spored or variable:

    Fuscous ... ... $5·7– 8·9 \times 5·1–7\,\mu$

    White non-fragrant ... ... $6·4– 8·9 \times 5·1–7\,\mu$

    White fragrant (two-spored) ... $6·4– 7·6 \times 5·1–5·7\,\mu$

SPORE GERMINATION

An enormous amount of work has been done by various investigators on the conditions conducive to the germination of spores of *Psalliota*. A good review of the literature up to 1924 can be found in Falck's paper (1924) and need not be gone into *in extenso* here.

Hoffmann (1860) is probably the first investigator who succeeded in germinating spores under controlled conditions, in water or damp air. He does not appear to have had any difficulty and remarks that there is nothing unusual about the germination of *Agaricus campestris*.

Attempts at mushroom culture under controlled conditions were first started in France. Chevreul (1861) and others tried test-tube cultures with very variable and uncertain results.

In America Duggar (1901) and Ferguson (1902) were the first to attempt to germinate the spores of various fungi including *A. campestris*, on media of known constitution, previously subjecting them to various treatments including artificial digestive fluids. Duggar, in his paper, employed the generic name *Agaricus* in the sense in which it is usually understood "by those interested in the practical side of the work", and gives no detailed description of the forms or varieties he worked with. This was of course before the days of pure spawn culture.

Both these investigators had very variable results. Ferguson, however, made the important discovery that germination could be stimulated by the introduction of small pieces of vigorous mycelium from a culture of the same species into the spore suspensions. She obtained her spores from sporophores just as the veil was about to break and again when the pileus was fully expanded or nearly so. She observed that spores from one spore-trace from a fully expanded sporophore raised in a conservatory, gave more uniform germination than those from any other spore-trace, but gives no further details as to the origin of the other prints, whether from cultivated forms or from the wild. She also noticed that when a high percentage of germination finally resulted it was always preceded a few days before by the germination of one or more spores. She was wholly unable to account for the irregularities in her results, but suggests that the maturity or other conditions of the spores must be the cause.

In 1924 Falck made a series of very elaborate experiments on the germination of spores of *Psalliota*, treating them with organic and inorganic acids, alkalis, etc., and obtained the best results in a mixture of 0·25 per cent. succinic acid and 10 per cent. malt extract. He repeated Ferguson's experiments and found that germination was stimulated by the introduction of mycelium of the same species. But, again, he gives no definite description of the form he dealt with.

After Falck, little further work appears to have been done on germination until Lambert in 1929 succeeded in isolating single spores of a cultivated variety "snow white", and in obtaining sporophores from single spore cultures, and from all possible combinations of them.

In 1930 Hein was able to germinate spores in distilled water, dung decoction and various synthetic media. The spores were obtained from mushrooms grown for experimental purposes in a specially constructed house. He gives no description of the variety used, but in all probability he was dealing with one or other of the cultivated forms.

The main object of this paper is to describe a method for spore collection and a simpler and fairly reliable method for inducing germination in the cultivated varieties but more especially in the wild

species *P. campestris*. The spores of the cultivated varieties germinate more readily than those of the wild species.

Without previous treatment, the spores require an incubation period of from six to seven days before they germinate, even under the best conditions; and, in order to avoid contaminations, the less they are handled before being placed in the solution in which they are to germinate the better.

Previous preliminary experiments on spore germination in Knop solution only, showed that the condition of the sporophore when the spore-trace is taken is of prime importance. The first shed spores of an immature sporophore do not germinate under artificial conditions. The pileus must be fully expanded and the gills umber, and consecutive traces should be taken from the same pileus at intervals of twelve to twenty-four hours. Therefore, it is advisable when gathering mushrooms in the open, not to gather the cap only, but to cut out the sod on which the cap is growing, so that it can continue to develop fairly normally for some days. The sod can either be left out
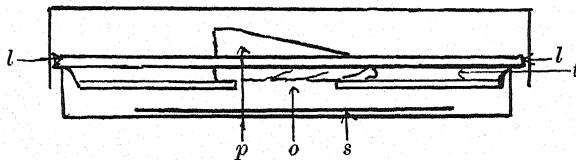
Text-fig. 2. Diagram of Petri dish fitted with tin tray and slide, and with sector of pileus in position for collecting spore trace. *l*, lip of tray resting on the edge of lower half of Petri dish; *o*, opening in the tray; *p*, sector of pileus; *s*, slide; *t*, tray.

of doors in a sheltered place, or brought into the laboratory and placed under a bell jar, which should be slightly tilted to ensure adequate ventilation without risk of drying out. If it is not possible to cut out the sod, the stipe should be pulled up gently and not cut. The pileus can be kept in a fresh condition by placing the base of the stipe on damp cotton wool in a small tube covered with a bell jar, again giving adequate ventilation. Sectors of the pileus can then be cut out when required.

The following is a method of collecting spore-traces free from contamination:

The quarter pound squat tins of Player's "Country Life" tobacco have lids which fit into a 4-in. Petri dish, so that the lip of the lid rests on the edge of the lower half of the dish, leaving a space of about ¼ in. between the lid and the base of the dish. The decoration can be easily removed with methylated spirit and a rectangle cut out of the centre of the lid. A sterile slide is then placed in a sterile Petri dish and the tin tray flamed and placed over the slide. A sector is then cut out of the pileus and placed over the slit in the tray and the lid of the dish replaced (Text-fig. 2). Sectors of large pilei do not

allow of the lid of the dish fitting down closely, but as long as the sector is large enough to cover the slit completely there is no risk of outside contamination of the trace. The slide with the spore-trace can be removed after the required interval and replaced by another, and a fresh sector of the pileus placed on the tray, and so on, until spore discharge ceases.

Before storing, the slides should be allowed to dry for twenty-four hours, then another sterile slide placed over the spore-trace and the two slides fixed together at one end with a sticking label, leaving the other free for opening when required. The slides should be wrapped tightly together in cellophane or clean paper, and stored in a dry cool place.

The spores of *P. campestris* remain viable for about six months, those of the cultivated varieties rather longer. Spores of the fragrant white variety have germinated after eight months and one spore-trace of the fuscous form gave some germination after fifteen months.

METHOD FOR GERMINATING THE SPORES

A hollow-ground slide is placed in a Petri dish on a circular piece of filter paper with an oblong cut out of the centre to coincide with the hollow in the slide. This eliminates the necessity of removing the slide from the dish for examination under the microscope. The dish is then sterilised. When sterile, a few drops of Knop solution are pipetted into the hollow of the slide, and a loopful of spores from a trace gently dipped into the liquid and not stirred, so that a number of spores remain floating on the surface. Although germination generally begins amongst the submerged spores, the floating spores appear to do better and grow faster.

The filter paper is then moistened with sterile water, the dishes placed on a sheet of glass under a bell jar lined with damp blotting paper and left to incubate undisturbed for about seven days at a temperature of 26–27° C. The Petri dishes should be marked with a wax pencil and not with sticking labels, as *Penicillium* and other impurities develop on the paper in a saturated atmosphere and considerably increase the risk of contamination when the dishes are opened.

Small pieces of vigorous mycelium may be placed at the edge of the Knop solution either at the time of sowing or seven to ten days after. The latter method was found to be the better in practice.

The objections to inserting the inoculum at sowing are that during the incubation period of seven to ten days the mycelium spreads all over the surface of the Knop solution and may absorb most of it, and also, when spores from a trace are capable of germinating without any inoculum, germination may be delayed for a few days.

If the inoculum is introduced after ten days, germination often starts within twenty-four to forty-eight hours and is much more even. The stimulus set up by the inoculum hardly extends beyond the tips of the hyphae, but once a few spores have germinated, a secondary stimulus is set up and germination spreads throughout the liquid.

If the sporelings are required for growing on, they should be taken out of the Knop solution as soon as possible and spread on a solid or semi-solid medium, from which they can be picked off singly or in groups and transferred to slopes of oatmeal agar.

Spore germination tests

Table II gives two series of germination tests with spores of the wild species *Psalliota campestris*, in Knop solution, with and without inocula from stipe cultures of the same species.

LS 7, LS 7*a*, and LS 7*b* are three consecutive spore-traces from a mature pileus with umber gills, taken at the intervals stated. It will be seen that in Knop solution only, without any inoculum, the spores of the first spore trace (LS 7) gave the best results on the eleventh day in series A, and some germination on the eighth day in series B. The third trace (LS 7*b*) gave little or no germination in B until the seventeenth day.

With the addition of inoculum at sowing, the second trace proved the best on the tenth day in series A, and gave some germination on the eighth day in series B. With the addition of inoculum on the tenth day the third trace (LS 7*b*) gave good germination in twenty-four hours in series A, and in B a percentage equal to that of LS 7 in series A.

The Knop solution in both series was not freshly made, but had been kept in tubes for some weeks before use.

It must be pointed out that these percentages were obtained from counts in microscope fields taken at random in the region within the influence of the stimulus set up by the inoculum, either underneath or round the edge of the mycelium. They are consequently merely rough estimations and only serve as a means of comparison between the effects produced by the different treatments. A true estimate of the percentages would entail spreading the spores from the suspensions daily on a solid or semi-solid medium for several days in succession, allowing them to incubate and counting them. Neither time nor incubator space would allow of this method being adopted with a large number of spore-traces; but, in one single instance, the percentage of germination was considerably increased by plating and counting the spores some days after germination had started in the suspensions.

Psalliota does not do well in a solution. After the germ tubes have

Table II A. *Germination tests in Knop solution.*
Spores 7 weeks 3 days old

Date ...	7th day	10th day		11th day			14th day		
Spore-trace, *P. campestris*	No inoculum	Inoculum added at sowing	Inoculum added after 10 days	No inoculum	Inoculum added at sowing	Inoculum added after 10 days	No inoculum	Inoculum added at sowing	Inoculum added after 10 days
				P. campestris with *P. campestris* inoculum. Medium Knop.					
LS 7, gills umber 1st 16 hr.	−	+ 31	−	+ 45·7 %	+	Occasional spore	‡	‡ 46·8 %	A little
LS 7a, 16–40½ hr.	−	++ 53 %	−	−	++ 59 %	Occasional spore	A little in patches	++	+ In patches
LS 7b, 40½–64 hr.	−	+	Occasional spore	−	++ 50·6 %	‡ 48·4 %	−	++	‡

Table II B. *Spore germination tests in Knop solution.*
Spores 8 weeks 6 days old

Date ...	7th day		8th day		10th day		17th day	
Spore-trace	No inoculum	Inoculum added at sowing	No inoculum	Inoculum added at sowing	No inoculum	Inoculum added at sowing	Inoculum added after 10 days	Inoculum added at sowing
		P. campestris with *P. campestris* inoculum. Medium Knop.						
LS 7	−	+ Occasional spore	+ Occasional spore	+	Occasional spore + inoculum added	−	56 %	25 %
LS 7a	−	−	−	A little + in patches	−	Nothing further	34·2 %	50 %
LS 7b	−	−	−	−	Inoculum added	−	27 %	59·5 %

attained a certain length, the spores are either pulled up to the surface of the liquid and there get caught up in the inoculum, or, if they remain submerged, the germ tubes die and disappear. If the inoculum is very vigorous, it is often necessary to draw it aside to expose the spores lying underneath, and a certain number of spore-lings are drawn away with it. This mainly accounts for the decrease in the percentages in series B after the twelfth day. Also after the germ tubes of the floating spores have attained a considerable length they become so entangled that they cannot be counted.

The patchy germination recorded in this table is most probably due to a secondary stimulus set up by the scattered germinating spores seen on the eleventh day and not to the stimulus set up by the inoculum.

Table III gives a more comprehensive series of germination tests, with inocula of the same and different species. The same spore-traces LS 7, LS 7*a*, LS 7*b* as in Table II are included, when the spores were four months old; also two spore-traces from another pileus of *P. cam-pestris* S 32, S 32*a*, gathered when the gills were not fully ripe but pinkish umber in colour. CP 4*a* is the second spore-trace of the white fragrant cultivated variety.

Table III. *Germination tests with inocula of the same species and different species*

Spore-trace *P. campestris*	No inoculum	Same species *P. campestris*		Different species *P. arvensis* cultivated	
		Inoculum same species added at sowing	Inoculum same species added after 7 days	Inoculum *P. arvensis* after 7 days	Inoculum fuscous form after 7 days
		Date: 10th day after sowing			
		Fresh Knop 23. ii. 35			
LS 7, + 1st 16 hr. gills umber	+	+	A few spores	+ Occasional spore	⧺ 36·3 %
LS 7*a*, + 16–40½ hr.	+ Occasional spore	−	+	+ Occasional spore	⧺ 32·9 %
LS 7*b*, + 40½–60 hr.	+	−	+	+ Occasional spore	+ Occasional spore
S 32, 1st 16 hr. gills pinkish umber	+ 1 spore	+ 1 spore	−	+ Occasional spore	+ Crystals; a little germ.
S 32*a*, 16–29 hr.	−	+ A few spores	+ A little germ.	−	+ Crystals; fair germ.
		White fragrant cultivated variety			
CP 4*a*, 17–37½ hr. gills umber	Contaminated with bacteria	+	⧺ 43 %	A few spores	+

Table III (*continued*)

Spore-trace P. campestris	No inoculum	Same species P. campestris		Different species P. arvensis cultivated	
		Inoculum same species added at sowing	Inoculum same species added after 7 days	Inoculum P. arvensis after 7 days	Inoculum fuscous form after 7 days
		Date: 12th day after sowing Fresh Knop 23. ii. 35			
LS 7, + 1st 16 hr. gills umber	+	+	+	+	╫ 50·8 %
LS 7a, + 16–40½ hr.	Occasional spore	—	+	Occasional spore	╫ 52·8 %
LS 7b, + 40½–60 hr.	+	Occasional spore	+	Occasional spore	╫ 28 %
S 32, 1st 16 hr. gills pinkish umber	+	Nothing further	+	Occasional spore	+ Crystals; nothing further
S 32a, 16–29 hr.	+	+ Occasional spore	+	—	+ Crystals; nothing further
		White fragrant cultivated variety			
CP 4a, 17–37½ hr. gills umber	— Bacteria	Crystals; nothing further	╫ 43·1 %	Early ╫ stages 44·9 %	╫ 40·0 %
		Date: 16th day after sowing Fresh Knop 23. ii. 35			
LS 7, + 1st 16 hr. gills umber	+ Early stages 17·7 %	Early stages 30·2 %	╫ Nothing further low %	+ 11·2 %	╫ 48·8 %
LS 7a, + 16–40½ hr.	+	+	+ Not countable	Nothing further	╫ 35 %
LS 7b, + 40½–60 hr.	+ Low %	+ Nothing further	+ 21·9 %	╫ 26 %	╫ 28·5 %
S 32, 1st 16 hr. gills pinkish umber	+ Nothing further	+ Nothing further	Early stages 12 %	+ Nothing further	+ Crystals; nothing further
S 32a, 16–29 hr.	+ Nothing further	+ Nothing further	+ Nothing further	+	+ Not countable
		White fragrant cultivated variety			
CP 4a, 17–37½ hr. gills umber	Occasional spore; bacteria	+ Nothing further	╫ Floating spores 33·4 %	╫ 36·8 %	╫ 41 %

LS 7, LS 7a, LS 7b, spores 4 months old.
S 32, S 32a, spores 4 months 10 days old.
CP 4a, spores 8 months 18 days old.

It will be seen that all the three traces of LS 7, although older than in Table II, have shown some germination on the tenth day in Knop solution only, but germination has been retarded in the spore suspensions of LS 7a and LS 7b by the inoculum introduced at sowing, and this retardation continues until the sixteenth day.

The inocula of *P. arvensis* introduced on the seventh day do not appear to produce any marked stimulatory effect, and the percentage recorded on the sixteenth day may be attributed mainly to the secondary stimulus set up by the presence of some germinating spores as in the controls without inoculum.

The stimulatory effect of inocula of the fuscous cultivated form, on the other hand, is very marked on the third day after the introduction of the inoculum, in the first two spore-traces of LS 7, and still more marked on the fifth day. The third trace LS 7b does not respond so readily, and the effect is not more pronounced than with inocula of *P. campestris* itself. In this series the first two traces have given the best results.

With regard to S 32 and S 32a the spores from pinkish umber gills, the percentages of germination are low throughout. The crystals recorded in the suspensions with the fuscous inocula require some explanation, as they produce an inhibiting effect which has to be taken into account. The aerial mycelium of both wild and cultivated forms of *Psalliota* is thickly encrusted with crystals, analysed by Hein (1930) and found to be calcium oxalate. The fuscous form produces a considerable amount of fluffy aerial mycelium on oatmeal agar. Some of this aerial mycelium was introduced in the inoculum, with the result that crystals were deposited in the Knop solution. These crystals dissolve slowly and completely alter the chemical constitution of the Knop solution and further germination is inhibited.

The effect produced by the different inocula on the fragrant white cultivated form CP 4a is interesting. The fuscous inoculum is not more potent than the inoculum of CP 4 itself, although they are both cultivated forms. Again, the suspensions containing crystals show inhibition of growth and further germination, and accidental contamination with bacteria is also deleterious. In other germination tests with CP 4a, this trace has shown that the spores are capable of germinating in Knop solution only.

Besides the tests recorded in Tables II and III, many other tests with spores of *P. campestris*, with and without inocula, have shown that success mainly depends upon the maturity of the sporophore when the traces are taken. During spore discharge from one and the same pileus, there appears to be an optimum germination period, either without inocula, or with certain varieties of inocula, and that this period can be shifted by subjecting the spores to other stimuli. Hence the advisability of taking consecutive spore-traces.

During this investigation most of the spore traces obtained by the method described on p. 231 have been free from contamination. Provided fresh, clean pilei are selected and due care exercised, the risk of contamination of spore traces from fully expanded pilei is not great.

Attempts at germinating spores of *P. arvensis* have failed. This is probably due to the lack of spores from mature sporophores, as the spores obtained at the beginning of this investigation were all from immature pilei, and the following autumn no further material was found.

<div align="center">DISCUSSION</div>

In view of the uncertainty about the origin of the cultivated varieties dealt with in this paper, no object is to be gained, at this juncture, by classing them as varieties of any one or other of the wild species *Psalliota campestris*, *P. arvensis*, *P. brunnescens*, etc., until proof is forthcoming whether they are or are not mere varieties. They are therefore described merely as cultivated forms of *Psalliota*. With the exception of the fuscous form, the other white cultivated forms more nearly approach *P. campestris*, than any other wild species met with so far.

It has been pointed out above that, apart from morphological characters, the main difference between the cultivated forms and the wild species is the number of spores on the basidium, and the number of nuclei in the mature spores. Lambert has shown that the spores of the cultivated "cream white" variety, with two-spored basidia, is monoecious; and since each spore receives two basidial nuclei, the spores are presumably in the diplophase. So far, there is no record of heterothallism in the genus *Psalliota*, but the fact that, in the four-spored wild species the spores receive only one instead of two basidial nuclei, and must consequently be definitely haploid, suggests that *P. campestris* and *P. arvensis* may be haplo-dioecious. Another possible difference between the wild and cultivated mushrooms may be that the cultivated forms can complete their life history from spore to spore as saprophytes, whereas there is some experimental evidence, not yet published, that a form of symbiosis exists between various grasses and the field mushroom *P. campestris*. Artificial inoculations under sterile conditions have shown that the mycelium can penetrate and live in the roots of grasses for a time without materially affecting the growth of the grass plants. It is not known how long this symbiotic balance persists; but, judging from the examination of roots from sods carrying pilei gathered in the open, the infected roots eventually die and are replaced by new growth in the root system. In the open, however, the grass evidently derives some benefit from the presence of the spawn of *P. campestris*,

as can be seen on fairy rings formed by this species. The grass on the rings is deeper green and of a more luxuriant growth than either inside or outside the ring. The mycelium of *P. arvensis* will also penetrate and live in grass roots, but in the open, the spawn is so profuse that it sets up physical and possibly chemical conditions, such as impermeability to water and excessive deposits of calcium oxalate, which are detrimental to the deeper rooted grasses.

SUMMARY

The basidia of the two wild species *Psalliota campestris* and *P. arvensis* and three different forms of cultivated mushrooms vary in the number of spores on the basidium. The wild species have four-spored basidia and the cultivated either two-spored or from one- to four-spored.

Only one out of these three cultivated varieties has shown uniformly two-spored basidia.

The number of nuclei in the mature spores of the wild species is constant; they contain two nuclei. In the cultivated variable varieties the number of nuclei may range from two to eight.

Methods are given for obtaining consecutive spore-traces from single pilei, for staining spores for nuclei, and for spore germination.

The stage of maturity of the sporophore when the spore-traces are taken is all important.

APPENDIX

DESCRIPTION OF TWO FORMS OF CULTIVATED MUSHROOM

By E. M. WAKEFIELD

White form

Pileus up to 7 cm. in diameter, at first hemispherical, then flattened-convex, margin incurved and extending beyond the gills.

Surface of pileus smooth, soft to the touch like a kid glove, under the lens appearing made up of silky fibrils, pure white, but becoming stained with brown when handled.

Flesh 12–13 mm. thick in the centre, attenuated towards the margin, white, solid, but less firm than in the brown form, becoming slightly pinkish when cut.

Lamellae crowded, reaching the stem but free from it, rounded behind, narrow, thin, at first pale, clear flesh-pink, becoming purplish brown (warm sepia (R)) as the spores mature.

Stipe 6–8 cm. long by $1\frac{1}{2}$–2 cm. broad, white, tinged rosy purple at the apex, smooth with a satiny sheen, equal or slightly incrassated at the base, becoming rufescent when rubbed.

Veil white, membranous, silky, thin and very frail, when ruptured leaving an irregular annulus on the stem.

Annulus median, white, at first broad and flaring upwards, but soon collapsing and eventually almost disappearing.

Basidia two-spored. Spores broadly elliptical, very variable in size, and also variable in colour, some being quite pale while others are more or less deep reddish brown.

Spore print dark brown (sepia (R)).

Spores 6·4–8·9 × 5·1–7 μ.

Brown form

Pileus up to 9 cm. broad, convex (flattened and hemispherical) when young, with margin strongly inrolled, becoming convex-expanded with age, with a slight depression in the centre.

Surface of pileus in the unopened state somewhat tomentose, avellaneous (R) in colour with sometimes, especially towards the disk, slightly broken up into scales. As the pileus expands the scales become more evident, and especially on handling or on drying the colour becomes deeper brown and the scales appear fibrillose and closer adpressed, especially towards the margin. Margin whitish and exceeding the gills, in expanded specimen often recurved, striate rim consisting of fragments of the veil.

Flesh very thick, compact, firm, whitish or tinged pinkish, becoming brownish when cut.

Lamellae crowded, free but reaching the stem, often appearing adnate at first, dull, dirty pinkish brown (approximately vinaceous fawn (R)) with a white edge due to tufts of clavate, hyaline hairs, later deep brown, almost black, narrow compared with the thickness of the flesh.

Stipe usually short and thick, 3–4 (–6?) × 2–3·5 cm. thick, whitish, smooth swollen, sometimes abruptly so at the base, which in indoor specimens may be woolly, solid, or rarely with a slight hollow, becoming brownish when cut or rubbed.

Veil thick, forming a soft, swollen median annulus which appears more or less triangular in vertical section, white and sulcate on the upper side, sometimes tinged with fawn colour below.
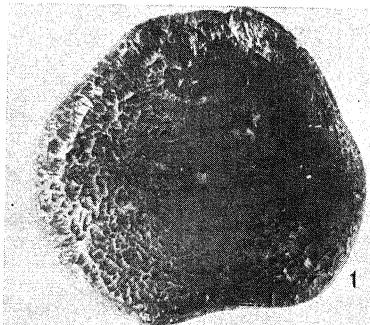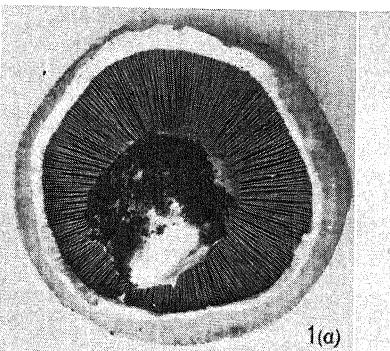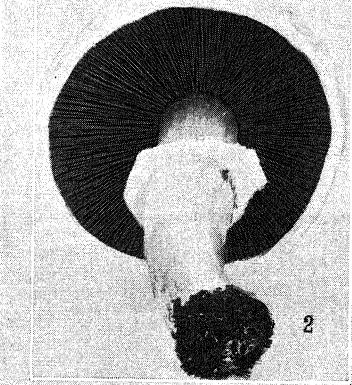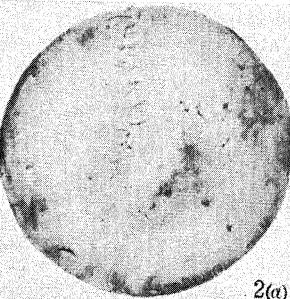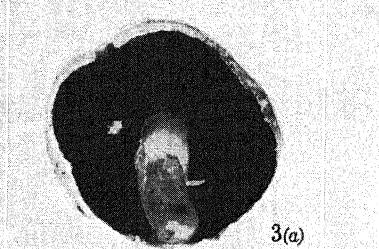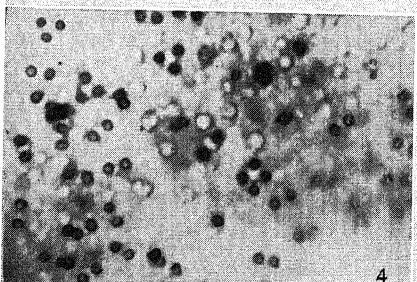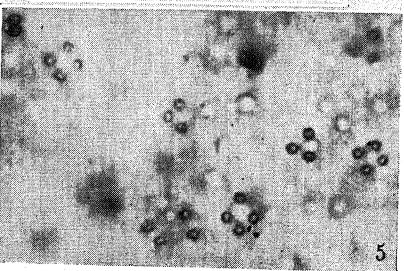
Basidia usually two-spored. Spores broadly elliptical, guttulate, rather thick walled, reddish brown by transmitted light, but giving an umber-brown spore print (sepia (R)).

Spores $5 \cdot 7 – 8 \cdot 9 \times 5 \cdot 1 – 7 \mu$.

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EXPLANATION OF PLATE III

Fig. 1, 1 *a*. Fuscous cultivated variety.

Fig. 2, 2 *a*. White non-fragrant cultivated variety.

Fig. 3, 3 *a*. Wild species, *Psalliota campestris*.

Fig. 4. Photomicrograph of young gill of white non-fragrant variety showing one- to four-spored basidia. × 140 approx.

Fig. 5. Photomicrograph of young gill of fuscous variety showing two- to four-spored basidia. × 140 approx.

THE PARASITISM OF *MYROTHECIUM RORIDUM* TODE

By N. C. PRESTON, B.Sc.

(With Plates IV and V)

DURING the summer of 1932 it was noticed that certain pansies in my garden appeared to be slowly dying out. First one shoot and then another gradually withered from the base upwards until by about August the whole plant was almost completely dead.

The stems had rotted at ground level and came away readily from the root which was more or less in a sound condition. On the basal portion of the dead shoots thus detached were numerous small black dots surrounded by a distinct white rim which proved to be the fructifications, sporodochia, of a *Myrothecium* closely approximating to the species usually determined as *M. roridum* Tode.[1]

The constancy with which these fructifications appeared on the dead and dying plants aroused suspicion that the fungus giving rise to them, though generally regarded as a saprophyte, might actually be the cause of the disease. A preliminary test was therefore made, before actually isolating the fungus, by transferring some of the spores from the centre of a sporodochium to the surface of the leaves of a growing potted plant of *Viola cornuta*. Within three days each of the leaves thus inoculated showed definite lesions in the form of dark purple spots, the centre of which rapidly became dry and brownish. In view of these immediately positive results the fungus was isolated in pure culture.

Pure cultures of the fungus were readily obtained by stirring up spores, taken with a sterile needle from the centre of a sporodochium, in a small quantity of sterile water and spreading a drop of this dilution upon the surface of a previously poured agar plate. After forty-eight hours' incubation at 22° C. the isolated growths could be readily picked out and transferred to agar slopes. In even the initial platings there was extremely little contamination though one or two bacterial colonies appeared. These were also isolated and dealt with separately.

The fungus cultures thus isolated were further tested for any bacterial contamination which might possibly have still been overlooked by taking spores from seven-day growths on malt agar and corn-meal agar respectively, suspending these in sterile distilled water and making poured plate cultures from them with plain nutrient agar.

[1] For this identification the author is indebted to Miss E. M. Wakefield.

These plates were kept at 22° C. and examined frequently. Both plates remained free from any visible bacterial colonies for four weeks, by which time there was a very abundant growth of the fungus mycelium upon them.

BACTERIAL INOCULATIONS

As far as could be readily ascertained the few bacterial colonies referred to above appeared to be those of a single organism and, though such colonies were actually very scarce in the initial plates, it seemed just possible that this organism might have been responsible for the lesions produced in the first rough experiment, and a test was therefore arranged as follows. Three shoots of a healthy plant of *Viola* growing in a pot were inoculated with the bacterium, while four others were similarly inoculated with spores from a pure culture of the fungus *Myrothecium roridum*. The inoculum consisted of a suspension in sterile water of spores or bacteria respectively, each being taken from an eight-day-old culture on cherry agar. A drop of the inoculum was placed upon the surface of the plant by means of a sterile platinum loop without any pricking or wounding of the tissues. Each shoot was inoculated upon two isolated internodes. All the shoots thus inoculated with the fungus spores developed characteristic lesions within eight days, while none appeared upon any of those inoculated with the bacterial suspension or elsewhere upon the plant.

INOCULATION EXPERIMENTS WITH THE FUNGUS

The second series of inoculations was carried out on September 9, again on a growing *Viola*. Two forms of inoculum were used, one a suspension of spores, the other a suspension of mycelial growth broken up in sterile distilled water. The mycelium for this purpose was taken from the fringe of an actively growing culture. Five stems were inoculated with the spore suspension and three stems with the mycelial suspension, the liquid being applied to the plant surface without any scraping or wounding, the plant being afterwards covered with a bell-jar to maintain a moist atmosphere. At the end of three days all the stems inoculated with the spore suspension showed characteristic purple-brown streaks on the internodes inoculated. Of the three stems inoculated with the mycelial suspension one showed a definite lesion comparable with those on the other five, on the second the lesion was apparent but much slighter, while on the third no lesion was visible. All the remaining uninoculated six stems of this same plant, which could be regarded as controls, remained perfectly normal.

This experiment has been described in detail because, in connection with it, a further test was made to eliminate any possibility of

bacterial contamination being a contributory cause of the lesions produced. This was done by placing a small quantity of each of the suspensions actually used for the inoculation in a sterile Petri dish and adding nutrient agar, previously cooled to 40° C. The plates thus prepared remained quite free from bacterial growth. In view of this result and the fact that the bacteria initially occurring naturally in the sporodochia failed to produce infection, it was considered unnecessary to subject the isolated fungus to any further tests of this nature.

The foregoing experiments were followed up by numerous other similar inoculations both on plants in pots and on detached leafy shoots. The stems, leaves, and basal parts were all subjected to inoculation with positive results. The varieties of *Viola* used were a mauve form, "Maggy Mott", a deep yellow, "Chantryland", and the small blue *V. cornuta*. No marked difference in susceptibility between these varieties was recorded.

It is not proposed to detail all the individual experiments, since the majority were carried out in a manner essentially similar to those already described, but reference to any significant diversions from this method will be made as is necessary.

As regards controls, in the earlier experiments a due proportion of leaves or internodes on the plant used for inoculation were treated with loopsful of sterile water in place of the spore suspension. Later, however, it was deemed satisfactory to regard all uninoculated parts as controls, the inoculated internodes or leaves being carefully marked by loops of thread. Where stem inoculations were made adjacent internodes were not selected for inoculation, the one or more internodes intervening between the inoculated ones thus serving as particularly useful controls. Such control parts invariably remained normal.

STEM AND LEAF INOCULATION OF GROWING PLANTS

(a) *Spore suspension applied without wounding or pricking of tissue*

Sixteen plants of varieties "Maggy Mott" and "Chantryland" were used in these experiments and ninety-one separate inoculations were made. The results may be summarised as follows:

Internodes inoculated 34; positive infections 25 = 73·5 per cent.
Leaves inoculated 57; positive infections 39 = 68·4 per cent.
Control parts, as described above, all normal.

(b) *Tissues pricked before inoculation. Exp.* 14 C

In a single plant, variety Chantryland, the stem and leaf tissues were lightly pricked with a sterile needle and the spore suspension applied in the usual way to the punctured surface.

Five internodes and four leaves (upper surface) were thus inoculated while the same number of each, similarly pricked but treated with drops of sterile water instead of spore suspension, served as controls.

All the inoculated internodes and leaves showed very pronounced lesions within eight days, the discolouring first becoming visible two days after inoculation. The pricked but uninoculated controls showed no discoloration whatever and remained perfectly normal throughout.

It is of interest to note, in connection with this experiment, that the plant described was one of a series of three, the other two of which were inoculated, unsuccessfully, in the usual way, *i.e.* without pricking. The inoculum for the three plants was prepared from an eleven weeks old culture. The effect on the three individual plants is here shown for comparison:

Plant A. 3 internodes inoculated without pricking: result 1 positive, 2 negative.

Plant B. 5 internodes and 4 leaves inoculated without pricking: result all negative.

Plant C. 5 internodes and 4 leaves inoculated after pricking: result all definitely positive.

The fact that all but one of the A and B inoculations proved negative may perhaps be accounted for by the age of the culture, since in a previous experiment, two days before, it proved similarly inactive giving only two positive results out of ten inoculations.

<div align="center">STEM AND LEAF INOCULATION OF DETACHED SHOOTS</div>

The inoculation of detached shoots of *Viola cornuta* was resorted to at times for convenience.

Only thoroughly healthy strong growing shoots were selected. These were well washed and placed in large covered glass dishes 20 cm. in diameter. The control shoots were sometimes contained in the same dish as those inoculated, sometimes in separate dishes, and in all the experiments here discussed they remained perfectly fresh and normal to the end. Fifteen shoots were used for inoculation.

Internodes inoculated 34; positive $21 = 61 \cdot 8$ per cent.

Leaves inoculated 35; positive $32 = 91 \cdot 4$ per cent.

Shoots kept as controls 11; all parts remained normal.

In one of these experiments the effect of a very dilute spore suspension was compared with that of a heavy suspension with the following result:

Dish *a*. 5 shoots. 15 internodes inoculated with weak suspension: positive 3, after 10 days.
10 leaves inoculated with weak suspension: positive 10, after 10 days.

Dish *b*. 5 shoots. 11 internodes inoculated (heavy suspension): posi-
tive 11, after 10 days.

10 leaves inoculated (heavy suspension): posi-
tive 10, after 10 days.

Dish *c*. 4 shoots. Uninoculated controls. All parts quite fresh and
healthy after 10 days.

In both (*a*) and (*b*) the characteristic discoloration began to be
apparent after three days. In (*b*), however, the lesions developed
much more rapidly; they were very marked on eight out of the eleven
internodes within three days, and all were obviously heavily infected
within seven days.

INOCULATION OF BASAL PARTS

Since this fungus first came under observation as the cause of a
basal rot it was obviously desirable to see whether a rot of this type
could be caused by surface inoculation with the pure culture. Some
experiments to determine this were therefore carried out, and these
will be best described individually.

Exp. No. 5. Two healthy rooted cuttings A and B of *Viola* var.
"Maggie Mott" in pots, were inoculated on February 23, 1933, with
material taken from a sixteen days old culture on potato-glycerin
agar. A heavy spore suspension was poured down the stem bases of
each plant and allowed to run into the surrounding soil and, in
addition, some mycelium from the same culture was carefully incor-
porated with the surface soil in each pot. A third plant C was
similarly treated with distilled water to serve as a control, and the
three plants were kept together in a cool greenhouse.

On March 27 all three plants, which superficially appeared equally
healthy, were lifted and the soil carefully washed from the roots; their
appearance was as follows:

Plant A. Main stem with pronounced dark lesion extending from
soil level to a height of 2 cm. Over the lower half of this lesion the
tissues appeared dark brown, wrinkled and rotting, the upper half
of the lesion being a purple-black discoloration. One of the lateral
shoots arising 3 cm. above the soil level was similarly blackened over
the length of the first internode. The roots and upper aerial parts
appeared normal.

Plant B. Apart from slight discoloration the main central shoot
appeared sound. Two lateral shoots were characteristically blackened
from soil level to a distance of about 2 cm. upwards. Both shoots
were rotting at the base. Roots and upper aerial parts were healthy.

Plant C. All parts above and below ground appeared quite
healthy. No discoloration apparent.

After examination each plant was transferred to a separate large covered glass dish. When the plants were examined two days later numerous sporodochia of *Myrothecium* were found to have developed upon the basal parts of the stems of plants A and B. Plant C still remained perfectly clean and normal in appearance.

Since the "Maggie Mott" plants were cuttings it seemed possible that they might be more readily susceptible to infection through the callused area than if they had been grown from seed. In further experiments therefore seedlings were used in place of cuttings.

Exp. No. 11. Six healthy *seedlings* of the yellow *Viola* var. "Chantryland", growing in 4-in. pots, were inoculated on August 4, 1934, with a spore suspension of an eight weeks old culture by allowing 3 c.c. of the suspension to run down the lower parts of the stems into the soil. Five similar control plants were treated in the same way with distilled water. The pots were then sunk in soil contained in two large boxes, the inoculated plants occupying one box the controls being in the other, and all were kept in the open.

On August 21 one of the inoculated plants and one control were lifted, washed and examined. Both appeared perfectly healthy and sound at the base. Ten days later (August 31) three more of the inoculated plants were lifted; these also appeared normal, as also did the still growing controls. After examination, these three plants were immediately transferred to covered glass dishes and used for a further experiment described later.

The remaining two inoculated and four control plants were allowed to grow for another seven weeks. When they were examined on October 18 the stem bases and upper parts of the roots of both the inoculated plants showed distinct signs of rotting from the exterior inwards. In addition to extensive discoloration of the stem bases the main tap root, for about 1 cm. from soil level downwards, was brown and discoloured, the discoloration merging gradually into the white firm tissue below.

All the four control plants were quite normal. Their stem bases were healthy, and it was particularly noticeable that the upper part of the root, which in the inoculated plants was badly affected, was here perfectly sound and white.

Exp. No. 11 *a.* The three plants from the previous experiment which had been transferred to glass dishes ten days after inoculation were used. Two of these, in dishes A and B, were further inoculated by running a few drops of fresh spore suspension on to the region between root and stem by means of a pipette, and a small fragment of mycelium was also applied at this point. The plant in the third dish C received no such inoculations and served as a control. On September 10 plant A showed only a scarcely perceptible darkening of the tissues at the point of inoculation, plant B was definitely rotting

at this region, while plant C, the control, remained white and normal.

Exp. No. 12. A single healthy "Chantryland" seedling was inoculated by pouring a spore suspension over the basal part as in previous experiments. A second plant was kept as an uninoculated control. Both plants were washed and examined three weeks after inoculation when their appearances were as follows:

Inoculated plant. Stem base blackening over a distance of 1 cm. from soil level upwards, the discoloration extending into one of the two secondary shoots. The lesion also continued downwards to a point ½ cm. below the soil level where the discoloration gradually diffused into the sound white tissue of the main root. Sporodochia were present in the middle of the main lesion.

Control plant. No lesion or discoloration was present, the normal greenish tinge of the stem base fading into the clean white of the healthy root.

Exp. No. 13. Three healthy "Chantryland" seedlings in 7 in. pots were used. From each of the three plants the soil was washed away at one side by means of a jet of water so as to expose the stem base and adjoining roots. One of the plants, A, was then pricked lightly on the exposed surface with a sterile needle and inoculated with spores from an eleven weeks old transfer by means of a platinum loop. The second plant, B, was similarly inoculated but without pricking, the third, C, was pricked but uninoculated. All three plants were washed and examined eighteen days later.

Plant A showed brown discoloration down the stem and root over 1·5 cm. Tissues below ground were clearly splitting and rotting.

Plant B showed a very slight discoloration at the inoculated region but no signs of rotting.

Plant C. Quite normal.

RECOVERY OF THE FUNGUS FROM ARTIFICIALLY INOCULATED PLANTS

In order to establish the parasitic nature of any fungus conclusively it is necessary to be able to reisolate it from the plant lesions produced by inoculation with the pure culture. This was done successfully with *Myrothecium roridum*. The first plant selected for this purpose was a "Maggie Mott" *Viola* which had been inoculated on August 27, 1932, and in which the characteristic lesions had been produced upon the stem. Eight days after inoculation a small fragment was removed from the drying centre of each of two stem lesions with the point of a flamed scalpel and the fragments of tissue transferred to two cherry agar plates. A pure growth of *Myrothecium roridum*, without any trace of contamination, developed upon each of the plates thus inoculated.

The somewhat rough and ready technique adopted in the foregoing experiment did not, however, absolutely preclude the possibility of the transference of a merely surface growth, or even perhaps of the spores of the fungus, to the agar plates, and a more elaborate procedure was adopted in the following later experiment.

On August 31, 1934, a "Chantryland" seedling was inoculated and kept under a bell-jar until September 4, when definite lesions had appeared on the stems and leaves. One of the stem lesions extended practically the length of an internode, appearing as an elliptical spot, brown and shrunken at the centre and sharply delimited by a purple-black border from the normal green tissue beyond. This internode measured 17×3 mm., the actual dimensions of the lesion being 12×2 mm. The following day a portion of the stem including the infected internode was cut away, immersed for one minute in $0 \cdot 1$ per cent. mercuric chloride, and thoroughly washed in sterile water. Fragments from the infected spot were then removed with a sterile scalpel and plated on cherry agar.

Two infected leaves, one from this same plant and the other from a second plant inoculated at the same time, were also taken. These were similarly treated with $0 \cdot 1$ per cent. mercuric chloride, washed in sterile water, and portions of the diseased tissue transferred to agar plates.

From each of the stem and leaf fragments thus plated a luxuriant mycelial growth was obtained and the typical spore masses of *M. roridum* developed after three days.

<center>DESCRIPTION OF THE FUNGUS</center>

Beyond the bare descriptions of *Myrothecium roridum* which are to be found in systematic works such as Rabenhorst's *Kryptogamen-Flora*, I have not been able to trace any literature dealing with this fungus, and no previous suggestion of its being actually parasitic seems to have been made. The following brief description may perhaps, therefore, not be out of place.

M. roridum is a member of the Tuberculariaceae, the genus being characterised by the presence of a ring of pure white setae around the margin of the sporodochium. The hyphae, in culture, are hyaline to pale brownish. The spores are straight with rounded ends, continuous and often contain two or sometimes three droplets. They are greenish or of a pale olive tint, appearing jet-black in the mass, and measure approximately $7-8 \times 2 \mu$.

The fungus grows well at room temperature on many kinds of artificial media, producing a flocculent growth of pure white aerial mycelium. Sporodochia are usually produced in abundance either on the substratum itself or among the loose aerial hyphae. When

lying separate from one another they appear as jet-black dots surrounded by a white rim. Often, however, they coalesce into larger masses and may sometimes form an almost continuous black line around the margin of the culture.

The lesions produced by inoculation of leaves or stems of *Viola* appear first of all as dark purple-black spots or streaks which gradually increase in extent. As the lesion advances the tissues at the centre become dry, shrivelled and brown, the outer margin being sharply delimited from the normal green of the leaf by a deep purple-black band.

Conclusions

From the experiments described it is clear that *Myrothecium roridum* can function as an active parasite. It is evidently able to enter the unwounded tissues of healthy plants of *Viola* and eventually to destroy them. Considering the ease with which infection can be secured and the rapidity with which the lesions develop under suitable conditions, it seems evident that this fungus must be reckoned as one of the possible causes of the dying out of violas under cultivation. This view is supported by the fact that the fungus occurs commonly upon dead or dying *Viola* stems from which it was actually isolated at the beginning of this investigation.

The method of inoculation adopted in the majority of the experiments shows that abrasion or wounding of the plant tissues is not necessary before infection can take place. That such injury would render a plant more liable to infection is, however, indicated by the results obtained in Exps. 13 and 14.

Since the fungus grows readily as a saprophyte not only on dead violas but also on many other kinds of plants, the possibility of infection spreading to violas from various other sources must be taken into account. In this connection it may be mentioned that a culture of *M. roridum* isolated from dead vine stems was found readily to infect healthy living plants of *Viola*.

Summary

Inoculation experiments with the fungus *Myrothecium roridum*, obtained in pure culture from dead *Viola* stems, are described.

A high percentage of infections was secured by applying a spore suspension to the uninjured tissues of healthy *Viola* plants.

The fungus was shown to be able to infect the leaves, stems and hypocotyledonary region of growing plants.

It is concluded that *Myrothecium roridum* must be regarded as a potential parasite under natural conditions.

Footnote. After this paper had been sent to the editors a preliminary account of a serious crown rot of snapdragons caused by *Myrothecium* appeared in *Phytopathology*, xxv (1935), 969—J. J. Taubenhaus: "On a black crown rot of greenhouse snapdragons caused by *Myrothecium roridum* Tode."
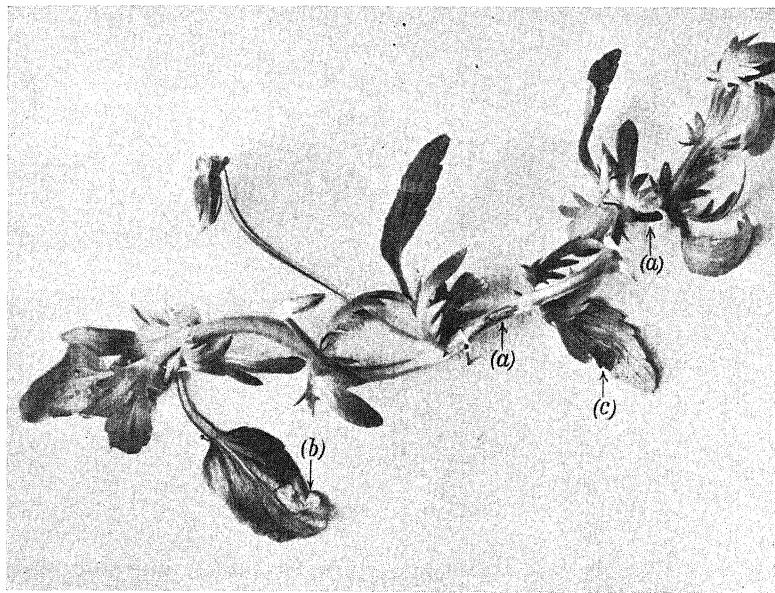
Fig. 1
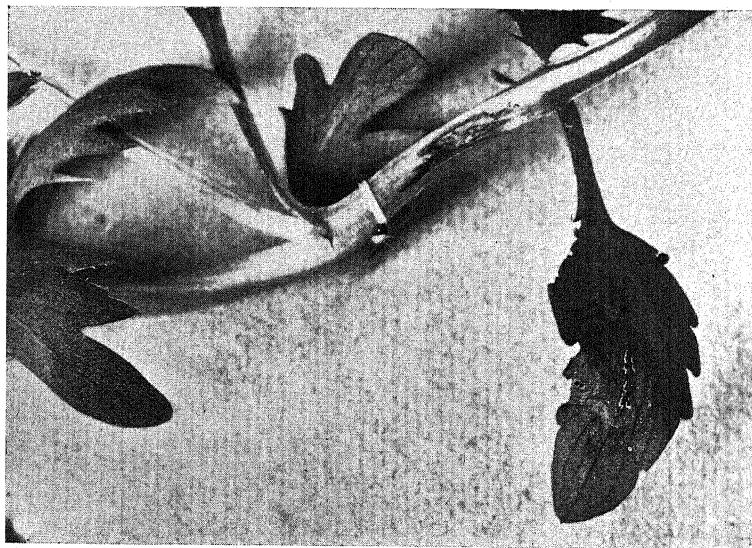
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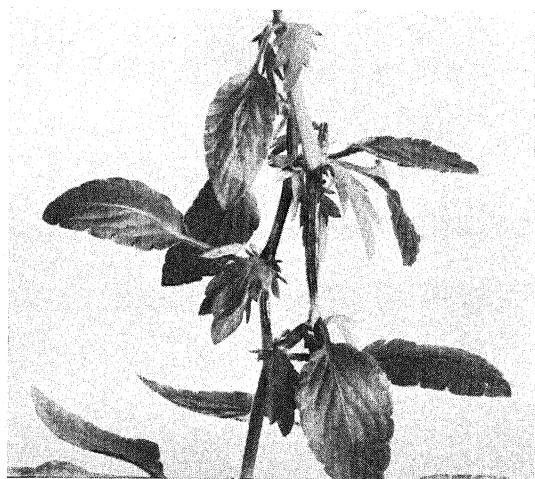
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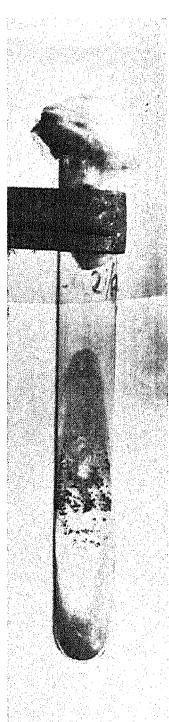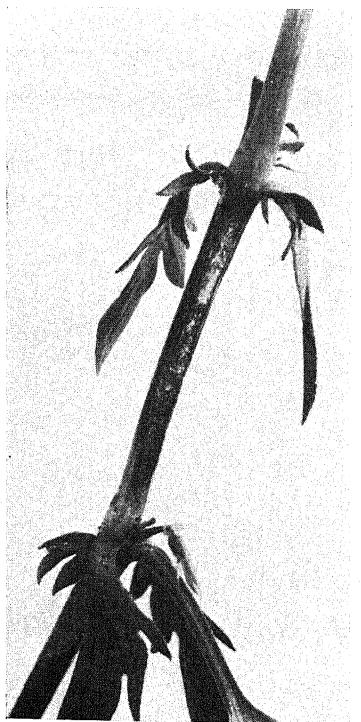
EXPLANATION OF PLATES IV AND V

PLATE IV

Fig. 1. *Viola* seedling, "Chantryland", artificially inoculated with *Myrothecium roridum* showing lesions on stem (*a*) and on leaves (*b*), (*c*). Lesions (*a*) and (*b*) six days, lesion (*c*) ten days after inoculation.

Fig. 2. Part of same plant as fig. 1 enlarged showing sporodochia on the inoculated leaf (*c*).

PLATE V

Fig. 3. *Viola* cutting, "Maggie Mott", showing artificially produced lesions (*a*) on the stem, fourteen days after inoculation.

Fig. 4. Extensive lesion on stem of "Maggie Mott" *Viola*, fourteen days after inoculation. Note concentric wrinkling at centre of lesion and the smooth healthy internode above the one inoculated.

Fig. 5. *Myrothecium roridum* Tode. Three weeks' growth on cherry agar.

OBSERVATIONS
ON THE RESULTS OF INOCULATING CEREALS
WITH THE SPORES OF CEREAL RUSTS WHICH
DO NOT USUALLY CAUSE THEIR INFECTION

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(With 18 Text-figures)

INTRODUCTION

THE study of specialisation among the cereal rusts was initiated by Eriksson as early as 1894, and since that time the subject has received much attention. Observations by early workers in different countries on the host range of particular rusts showed unaccountable discrepancies, which became explicable only after the recognition of numerous physiologic forms of the different rusts, the existence of which was first demonstrated in *Puccinia graminis Tritici* by Stakman and Piemeisel in 1917.

Our knowledge of the specialisation and host range of the different cereal rusts is largely based on macroscopic observations of the infected hosts, and consequently the reaction between host and parasite has been defined merely in terms of such visible symptoms as necrosis, flecking, and pustule formation. Such observations give only an incomplete picture of the development of the fungus and its relationship with the host tissues.

The first careful investigations of the intimate relationship existing between host and rust were made by Marshall Ward in 1901 and 1902. Gibson found, in 1904, that chrysanthemum rust could enter various plants on which it does not normally occur. However, no true infections resulted, that is, no haustoria were formed, and by the end of the fourth day the fungus was dead. Killed host cells were observed in the vicinity of these hyphae, and Gibson suggested that the death of the hyphae was due to some poisonous substance emitted by the cells.

Marryat, in 1908, studied two varieties of wheat showing different degrees of resistance to yellow rust, *P. glumarum*. She found that the fungus entered these plants in a normal manner and produced hyphae, but development was restricted owing to the death of host tissue in the infected areas, which cut off the food supply of the parasite. In the variety "American Club", which was the less resistant, the fungus developed further but ultimately death resulted.

Stakman, in 1914 and 1915, studied the development of stem rust

of wheat on immune and susceptible varieties of that host. He was the first to study microscopically the several forms of *P. graminis* on hosts presenting an extreme degree of incompatibility. These studies included oats inoculated with *P. graminis Tritici* and *P. graminis Hordei*; rye, wheat, and barley inoculated with *P. graminis* from *Dactylis glomerata*; and wheat inoculated with *Puccinia graminis Avenae.* The experiments showed that the fungi entered "practically immune" plants in a normal manner, but after the death of a number of host cells they were unable to develop further. Stakman termed such host plants "hypersensitive". He states that immunity and resistance are independent of the state of nutrition of the host,[1] but that the explanation probably lies in the secretion of toxins by host, or parasite, or both.

Newton, in 1922, studying *P. graminis Tritici*, showed that a resistant variety of wheat exhibited the same intolerance to the fungus as described by Stakman (20). She, however, interpreted the early cessation in the development of the fungus as being due to starvation resulting from the death of host tissue.

More recently, Allen, in 1923 and 1926, contributed valuable information regarding the host-parasite relation by means of cytological studies of different physiologic forms of *P. graminis Tritici* on varieties of wheat showing various degrees of susceptibility and immunity. Entry of the fungus was always observed, but even in susceptible varieties the guard cells of the stomata of entry were often killed. The subsequent development of the rust varied. Khapli emmer, a variety of wheat resistant to all forms of *P. graminis*, was inoculated with forms 9, 21 and 27. The first mesophyll cell invaded always collapsed and died but the fungus survived, and occasionally produced minute uredo pustules. In addition to microscopic studies of immune and susceptible varieties of wheat inoculated with *P. graminis Tritici*, Allen, in 1926 and 1927, made cytological studies of Little Club wheat (susceptible) and Malakoff wheat (resistant) inoculated with *P. triticina* P.F. 11.

Ruttle and Fraser, in 1927, studied in detail a resistant and a susceptible variety of oats inoculated with *P. coronata* Corda. They found that the entry of the fungus was similar in both varieties. In Cowra 35, the resistant host, the first cell invaded was killed, but sometimes the fungus continued to develop and eventually produced minute pustules as recorded in *P. triticina* on Malakoff wheat (5), and *P. graminis Tritici* on Khapli emmer (3).

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[1] The recent work of Forward, in 1932 (*Phytopathology*, xxii, 493–555), seems to render this view untenable, since she was able to produce changes in infection type with *P. graminis Tritici* P.F. 21 as a result of altering the host metabolism by starvation. For example, after prolonged periods of darkness, hypersensitive areas appeared on hosts which were ordinarily congenial.

The above account shows that we have little information concerning the development of cereal rusts in an extended range of plants. The experiments of Stakman (19, 20) with *P. graminis* apparently provide the only existing account of the development of cereal rusts on hosts on which they are not normally found in nature ("inappropriate hosts"). Most other workers have restricted their experiments to immune and susceptible varieties of the natural host.

The work now presented was designed to supplement existing knowledge concerning this aspect of the problem of specialisation among the cereal rusts.

MATERIALS AND METHODS

Inoculation experiments were carried out with uredospores of the following rusts:

Puccinia triticina Erikss. (brown or leaf rust of wheat).
P. glumarum Tritici Erikss. (yellow or stripe rust of wheat).
P. anomala Rostrup (brown or dwarf rust of barley).
P. coronata Corda (crown rust of oats).
P. graminis Secalis Erikss. (black or stem rust of rye).

In addition, aecidiospores (*P. coronata* Corda) from *Rhamnus catharticus* and *R. Frangula* provided the inoculum for some experiments.

The particular physiologic forms of the fungi used in these investigations are not known, as no work had been done in England on their determination at the time these researches were carried out.

All plants used for inoculation were grown in 4-in. pots in greenhouses and were from one to three weeks old at the time of inoculation. They included wheat, rye, barley, and oats, and, in some experiments, certain grasses in addition.

All the seeds showed excellent germination, except those of *Agropyron repens*, which proved to be unreliable. Young plants of this grass were obtained, however, by potting pieces of rhizome.

In experimenting with hosts which were susceptible to more than one form of rust used, it was necessary to guard against accidental infection. As far as possible, therefore, experiments with different rusts were carried on in different greenhouses. Cultures of the various rusts were established on their appropriate hosts and were maintained in the greenhouses. In a few experiments spores were taken directly from the field and used for inoculation.

For easy reference the details of experiments are set out in tabular form. In these tables the cultural history of the rust used is given in an abbreviated form; for example, G 6 from wheat indicates that the particular rust has been cultured for six successive generations on wheat; G 4 from oats indicates that the rust has been cultured on oats for four successive generations.

At the time of each experiment the germination capacity of the spores used was tested by sowing them on tap water in watch-glasses. Spores frequently showed 100 per cent. germination under these conditions, but it did not necessarily follow from this that even susceptible plants would be heavily infected.

Inoculations were made with a sterile scalpel, only the first leaf of each seedling being inoculated. All inoculated areas were marked with waterproof ink, and the plants were placed in a moist chamber for forty-eight hours after inoculation.

In some experiments the inoculated plants were observed only macroscopically, while in others areas were removed at intervals after inoculation. These were fixed, embedded in paraffin wax (M.P. 50° C.) and sectioned. Cedarwood oil was used instead of xylol for embedding, as the material was then less brittle. Several fixatives were tried, including formol-acetic-alcohol, chrom-acetic, and chrom-acetic-urea of different strengths. Consistently better fixations were obtained with Allen's (2) chrom-acetic-urea, made up in the following proportions: 1 gm. acetic acid, 1 gm. chromic acid, and 0·5 gm. urea in 100 c.c. distilled water.

Sections were cut 10 μ in thickness. For staining the following combinations were tried: Heidenhain's iron-alum haematoxylin and orange G; Flemming's triple stain; and diamant fuchsin and light green. The diamant fuchsin and light green combination was best and was used almost exclusively.

INVESTIGATIONS

Section I. *Puccinia triticina* Erikss.

In 1907 Pole-Evans published an account of the histology of *P. triticina*. Detailed cytological studies of this rust both on a susceptible and a resistant variety of wheat were made by Allen in 1926 and 1927.

P. triticina was collected at the University Farm, Cambridge, on October 11, 1927. The first transfer was made to seedlings of Wilhelmina wheat in the greenhouse and an excellent crop of spores developed. By successive transfers to Wilhelmina wheat the culture was maintained for two and a half years.

The experiments with *P. triticina* were more numerous than those with other rust forms, since an abundance of spores from greenhouse cultures was always available. Inoculations were carried out on wheat, rye, barley, and oats. The varieties used were Wilhelmina, and occasionally Persian Black wheat; rye of unknown variety; Spratt Archer barley; and Grey Winter oats.

(1) Experiments for Macroscopic Study of Inoculated Plants

Inoculations were made on wheat, rye, barley, and oats, but no inoculated areas were fixed. Daily observations were made on all plants. Thirty-five experiments were made, of which twelve representative ones are described in Table I.

Wheat. In the thirty-six experiments in which wheat seedlings were inoculated with spores of *P. triticina* heavy crops of spores resulted in thirty-three; in all but one of these, all the seedlings inoculated were infected. In three experiments no infection resulted, and in two of these the failure of infection was correlated with very low germination of the inoculum.

Rye. In the thirty-four experiments in which rye seedlings were inoculated, macroscopic observation showed that infections resulted in all but five. There was, however, a striking variation in the type of infection from one experiment to another. These experiments fall roughly into the following classes:

(1) Normal infection, as in wheat, resulting in a heavy crop of spores, and without necrosis. Five experiments, in which fifty-six out of fifty-eight inoculated plants were heavily infected.

(2) Weak infection resulting in small pustules with no necrosis. Three experiments in which only four out of twenty-seven plants produced pustules.

(3) Mixed infections in which some leaves produced heavy crops of spores with no necrosis, while others produced few or no spores and showed considerable necrosis. Four experiments in which twenty-nine out of forty plants produced pustules.

(4) Infections resulting in minute pustules on a few leaves accompanied by necrosis, and large necrotic areas on most of the inoculated leaves.

(5) Infections resulting in no pustules but considerable necrosis.

Consideration of the data concerning these experiments has failed to reveal any clue as to the nature of the factors which govern the type of infection on rye.

Barley. In the twelve experiments in which barley seedlings were inoculated, weak infections resulting in minute pustules occurred in three. There was no necrosis on barley.

The total number of barley plants inoculated in these experiments was 111, and of these ten became weakly infected.

In the single experiment (No. 10) in which spores produced on barley were used as the inoculum, no infection resulted on barley seedlings.

Oats. In the eleven experiments in which 111 oat seedlings were inoculated no definite sign of infection was observed, although one plant showed flecking.

Table I. Puccinia triticina. *Experiments for macroscopic study*

Exp. No.	Date	Plants inoculated	Culture used	Results
1	Jan. 9, 1928	Wheat* Rye Barley Oats	G 2 from wheat Germ. 100 %	Wheat 10/10,† good infection Rye 1/10, weak infection Barley 0/10 Oats 0/10
2	Feb. 25, 1928	Wheat Rye	G 3 from wheat Germ. 100 %	Wheat 12/12, good infection Rye 1/12, weak infection. Large necrotic patches on many leaves of rye
3	June 15, 1928	Wheat Rye	G 7 from wheat Germ. 50 %	Wheat 20/20, good infection Rye 0/20 (no necrosis)
4	Aug. 6, 1928	Wheat Rye	G 1 from Wil. taken from P.B. wheat Germ. 78 %	Wheat 16/16, good infection Rye 20/20, good infection. Some rye leaves quite as heavily infected as wheat. No sign of necrosis on rye but a few plants were more definitely flecked than wheat. The flecks were normal in appearance
5	Aug. 28, 1928	Wheat (P.B.) (Wil.) Rye Barley Oats	G 4 from P.B. Germ 75 %	Wheat (P.B.) 10/10, good infection; (Wil.) 10/10, good infection Rye 2/10, poor. Large necrotic patches on some inoculated leaves. Barley 1/10, weak infection. A few minute scattered pustules; first positive infection of barley with *P. triticina* Oats 0/10
6	June 11, 1929	Wheat Rye	G 12 from wheat Germ. 100 %	Wheat 12/12, good infection Rye 12/12, good infection. Slight necrosis. Pustules on both hosts 7 days after inoculation
7	June 26, 1929	Wheat Rye Barley Oats	G 13 from wheat Germ. 100 %	All plants showed definite flecking on 6th day Wheat 20/20, good infection Rye 20/20, good infection, no necrosis on rye Barley, oats, no pustules
8	July 14, 1929	Wheat Rye	G 14 from wheat Germ. 100 %	Wheat 10/10, good infection Rye 0/10, necrosis
9	July 19, 1929	Wheat Rye Oats Barley	G 14 from wheat Germ. 20 %	Wheat 10/10, good infection Rye 5/10, weak infection, necrosis Barley 5/10, weak infection, very small pustules but no necrosis Oats 0/10
10	Aug. 2, 1929	Barley	G 1 from barley (transferred from wheat), very few spores available	No sign of infection after 3 weeks
11	Aug. 7, 1929	Wheat Rye	G 15 from wheat Germ. 100 %	Wheat 10/10, good infection Rye 10/10, good infection. 5 leaves produced large pustules and infection appeared normal: on the other 5, pustules were smaller and there was some necrosis
12	Aug. 25, 1929	Wheat Rye Barley Oats	G 16 from wheat Germ. 100 %	Wheat 9/9, good infection Rye 6/6, good infection; smaller pustules but no necrosis Barley 4/10, very minute pustules but no necrosis Oats 0/10

* Wheat: unless Persian Black (P.B.) is specified, the variety used was Wilhelmina (Wil.).

† The denominator of the fraction represents the number of plants inoculated, the numerator the number which produced pustules. Unless stated there was no sign of flecking on the plants which did not produce pustules.

(2) Experiments for Microscopic Study of Inoculated Plants

These experiments were carried out in order to follow microscopically the development of *P. triticina* in wheat, rye, barley, and oats. Seedlings were inoculated as before, and marked areas were removed at intervals and prepared for microscopic examination. The varieties used were the same as before, only one variety of wheat (Wilhelmina) being used for microscopic study.

The details of the experiments are given in Table II.

Table II. *Puccinia triticina. Experiments for microscopic study*

Exp. No.	Date	Plants inoculated	Culture used	Times of fixations: days after inoculation	Remarks on macroscopic appearance of leaf areas at the times of fixation
36	Jan. 9, 1928	Wheat Rye Barley Oats	G 2 from Wil. wheat	2 3 5 7	Flecking on wheat only
				10	Pustules on wheat only
				21	Pustules on wheat only. Necrotic patches on rye which had appeared as small flecks on the 13th day. No sign of infection on barley or oats
37	Feb. 25, 1928	Wheat Rye	G 3 from Wil. wheat	17	Numerous pustules on wheat. Definite necrosis on inoculated leaves of rye, and a few minute pustules on one leaf
38	June 17, 1929	Wheat Rye	G 11 from Wil. wheat	1	Flecking on wheat
				2	—
				3	Flecking on wheat and rye
				4 8	— Numerous pustules on wheat. Numerous pustules on some leaves of rye, but fewer and smaller pustules on others accompanied by necrotic patches
39	June 26, 1929	Wheat Rye Barley Oats	G 13 from Wil. wheat	10	Numerous pustules on wheat and rye. No pustules on barley and oats, but definite flecking
40	July 1, 1929	Wheat Barley Oats	G 13 from Wil. wheat	1 2 3	No flecking
				4 6	Flecks on wheat only —
				10	Numerous pustules on wheat. No sign of infection on barley or oats
41	Sept. 28, 1929	Wheat Rye Barley Oats	G 19 from Wil. wheat	1	No flecking
				2	Faint flecking on wheat only
				4	Definite flecking on wheat only
				6	Wheat as above. A few flecks on rye, but none on barley or oats
				8	No sign of pustules. A few faint flecks on barley
				11	Numerous pustules on wheat. Necrotic patches on rye; no pustules
				17	Numerous pustules on wheat. A few small pustules on rye and large necrotic patches. A few minute pustules on barley and no sign of necrosis. Very faint flecking on oats but no sign of pustules

The data given in the last column of the Table show that the rate of development of *P. triticina* in these plants varied from one experiment to another. The following accounts of the development of the fungus are generalised from the different experiments, but variations in the developmental rate will be indicated.

A study was first made of the progress of the fungus in wheat, the original host. This study provided a basis for comparing its progress in rye, barley and oats.

Development of Puccinia triticina *in wheat*

During the first twenty-four hours many of the spores germinated. Appressoria were formed over the stomata, and the contents of these passed into vesicles in the substomatal cavities. The stomata of entry were not damaged by the fungus. By the second day infecting hyphae were seen growing toward the mesophyll cells, and on the third day many had formed haustoria.

Fig. 1 (three-day material) shows an entry which is typical of those found in wheat. Here the vesicle is almost empty. The infecting hypha branched into two shortly after its formation. Both branches were closely applied to the walls of mesophyll cells. The first haustorial mother cell (now empty) was cut off at the tip of branch *a*. This produced haustorium *d*, which lay in close contact with the host cell nucleus *e*. Hypha *f* arose just behind the haustorial mother cell. It was full of contents and lay across the invaded host cell. Branch *b* of the infecting hypha was much longer than *a*, but had formed no haustoria *b* at the time of fixation. Hypha *b* was full of contents and showed very clearly the groups of three nuclei which are characteristic of the mycelium of *P. triticina* as noted by Allen (4). There was no disturbance of the surrounding tissues.

Fig. 1. (×315.)

After establishing contact with the host tissue by the formation of the first haustorium, the fungus grew rapidly. New hyphae and haustoria continued to develop, and by the fourth day an intimate relation was established with the host. From the seventh day dense wefts of hyphae, in preparation for pustule formation, occurred at intervals below the upper and lower epidermis. Even at this stage the host cells retained their normal appearance. By the eighth day
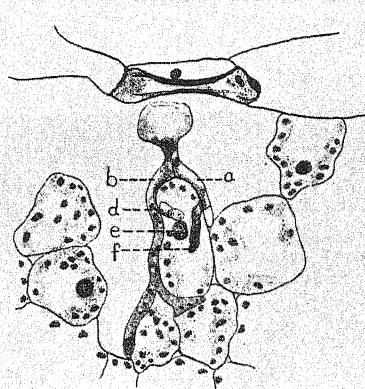
many pustules had developed. Hyphae in the tissue below the pustules were empty and frequently septate, and large haustoria were present in the host cells. Mesophyll cells in the pustule region were still living, and retained their contents. As noted by Allen (4), a few dead host cells were occasionally found in the vicinity of pustules, apparently crushed by the great mass of hyphae formed.

The development of *P. triticina* on Wilhelmina wheat has been described briefly, since its development on this host agrees closely with that described by Allen for the rust on Little Club wheat, a susceptible variety.

Development of Puccinia triticina *in rye*

Different types of reaction may occur between rye and *P. triticina*. This is clear from the macroscopic observations recorded in Table II. Different types of reaction might occur on different leaves of the same plant, or on different parts of the same leaf.

The variability in the type of infection in rye became evident from the macroscopic observations, some of which are set out in Table I; microscopic study serves to distinguish four different types of reaction in rye, A, B, C and D. These reaction types showed differences in the development attained by the fungus, its relation with the host tissue, and the final fate of the intercellular mycelium.

Type A reaction in rye.

The spores germinated, formed appressoria, and many of the fungi entered the leaves during the first twenty-four hours without damaging the stomata. Vesicles with their infecting hyphae were numerous in the substomatal cavities, and by the second day some of these had formed haustoria in host cells.

Fig. 2 (from two-day material) shows entry into rye at this time. Two empty appressoria can be seen outside a stoma, and two vesicles with their infecting hyphae in the substomatal cavity. Infecting hypha *a* has already formed a haustorium *d*, which lies in contact with a host nucleus, and the terminal haustorial mother cell is now empty. Other infecting hyphae were sometimes branched. No harm was done to the mesophyll cells.

Fig. 2. (×315.)

In one leaf area of rye fixed on the second day, the fungus had already developed several healthy-looking hyphae, a stage of development not usually reached in wheat until the third or fourth day.
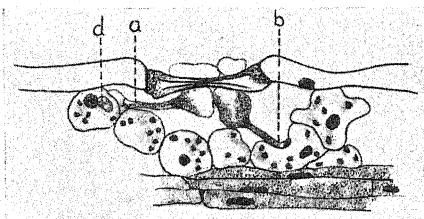
In some leaf areas (Exp. No. 38) the fungus was well established by the fourth day, and its relation with the host appeared to be quite congenial.

By the seventh day the intercellular hyphae had spread considerably and formed wefts of mycelium beneath the upper and the lower epidermis. The hyphae were now mostly empty and septate, and large haustoria were seen in the host cells. By the eighth day many pustules had formed. In Exp. No. 38 these were, in general, smaller than those on wheat, but otherwise similar. In Exp. No. 39 large pustules were produced on both surfaces of the leaves.

In type A reaction, the development of *P. triticina* in rye is the same as in wheat, the relation between host and parasite remaining congenial throughout.
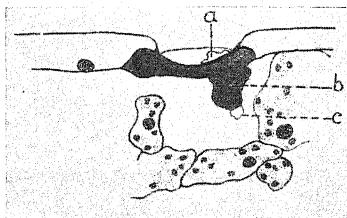
Fig. 3. (×315.)
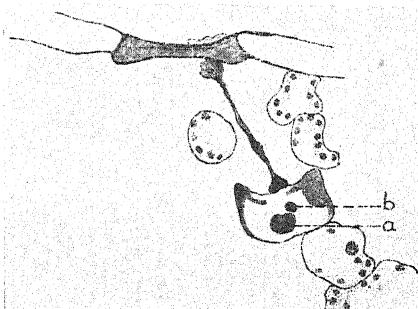
Fig. 4. (×315.)

Type B reaction in rye.

An examination of leaf areas from several experiments showed that sometimes *P. triticina* made only restricted progress in rye, in contrast to the development which has been described under type A reaction.

The fungus entered as before, but the guard cells of the stomata of entry were usually dead and discoloured. Many vesicles in material fixed after twenty-four hours retained their contents, but these were frequently deeply stained and no infecting hyphae had developed.

Fig. 3 (twenty-four-hour material) shows one of these vesicles. The guard cell, seen in section, is dead, and the shrivelled remains of the appressorium *a* are outside. The vesicle *b* is dead, and very deeply stained. The projection at *c* is probably the rudiment of an infecting hypha.

For three weeks after inoculation, vesicles were seen in the substomatal cavities. Some produced infecting hyphae, and occasionally a haustorium was developed.

A later entry is shown in Fig. 4 (from seventeen-day material).

Here the infecting hypha produced a haustorium *a* in the first host cell encountered. This cell (nucleus, *b*) is now dead and the fungus is considerably shrivelled.

These figures illustrate the maximum development of the fungus in type B reaction. The fungus did not succeed in establishing itself in the host tissue; there was no development after the formation of the infecting hypha, which only occasionally produced a haustorium. It was clear that in this type of reaction an antagonistic relation existed between the fungus and host. Only slight damage was done to the host tissue, since at most only two or three host cells were killed.
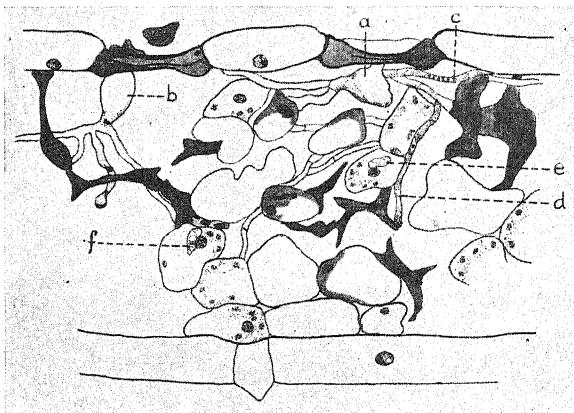
Fig. 5. (×315.)

Type C reaction in rye.

In this type of reaction, as in type B, the relation between rust and host was definitely antagonistic. The fungus, although it did not develop so far as to produce pustules, made considerably more progress than in type B reaction, and consequently larger areas of leaf tissue were damaged, forming visible necrotic patches.

In leaf areas where type C reaction was observed many of the entries showed the type B reaction. Some entries, however, succeeded in establishing an intercellular mycelium, and the vesicles with their infecting hyphae were found empty in the substomatal cavities. If now the mycelium developed, type C reaction was encountered. The characteristics of this type of reaction are shown in Fig. 5 (eleven-day material), where two separate entries are seen at neighbouring stomata. The guard cells are dead. The vesicles *a* and *b* are practically empty. A few intercellular hyphae resulting from these entries can be seen, some (*c* and *d*) retaining their contents while others are

empty. Haustoria can be seen at *e* and *f*, but very few host cells are living. Some are shrunken and so deeply stained that it is impossible to distinguish the contents, while others are empty. Similar empty cells were found by Allen (5), when Malakoff, a resistant variety of wheat, became infected with *P. triticina* P.F. 11. Such infected zones of leaf tissue are local and are separated by zones of healthy cells. The abundance of non-functioning haustorial mother cells is a striking feature of many of the zones exhibiting the type C reaction.

In type C reaction antagonism existed between the fungus and rye, damage done to the host involving considerable areas of leaf tissue. The condition of the fungus itself was weak, and there were no signs of pustules.
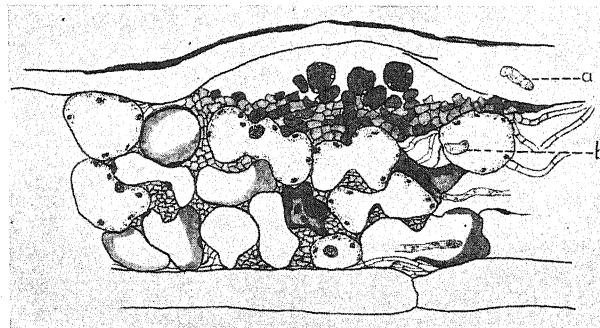
Fig. 6. (×315.)

Type D reaction in rye.

Type D reaction resembles most closely type C, but differs from it in that the fungus succeeded in producing a few minute pustules in the necrotic areas. These appeared in Exp. No. 41, for example, sixteen days after inoculation, whereas pustules appeared on wheat on the eleventh day.

The relation between rye and the rust in type D reaction is illustrated in Fig. 6 (seventeen-day material). Some host cells are empty; others are shrunken and have deeply stained contents; still others are characterised by irregular thickenings of their walls. (Such thickenings were also observed in type C reaction.) They correspond closely to the "swellings" and "warts" described by Allen (5) as occurring outside the infected zones of Malakoff wheat. In rye, however, these swellings were found directly in the infected areas. Fragments of hyphae seen in the tissue have sparse, vacuolated contents, or none at all. Very few haustoria were formed; two are shown, one in an epidermal cell at *a*, and one in a mesophyll cell at *b*. Although small pustules were formed, few spores reached maturity.

Development of P. triticina *in barley*

The rust enters barley as freely as it does wheat and rye. Actual counts were not made, but by the end of the first day vesicles were numerous in the substomatal cavities and the stomata were not damaged. New vesicles continued to develop during the first eight days after inoculation. The fate of most of these became clear from a study of later fixations in which numerous dead and shrivelled vesicles with infecting hyphae were often found in the substomatal cavities, death having occurred before relation was established with the host. These entries were similar to some in type B reaction in rye, except that in barley the guard cells were not killed (cf. Fig. 4).

Barley fixed seventeen days after inoculation in Exp. No. 41 showed zonal infection similar to that described in type D reaction in rye. In barley there were fewer dead cells, indicating that the reaction in barley was less violent than in rye. Only rarely did a few minute pustules develop in barley, and these were considerably aborted. On the rare occasions where *P. triticina* reached the reproductive stage in barley, there was an antagonistic relation between barley and the rust.

Development of Puccinia triticina *in oats*

The rust entered oats freely, forming numerous vesicles in the substomatal chambers. The stomata were not damaged. Frequently two or more vesicles were found in the same cavity, and occasionally infecting hyphae were found.

Some entries seen in oats showed disturbance of the surrounding mesophyll cells although no haustoria had been formed. The rust made little progress in oats, and only once was a small haustorium seen, marking the most advanced stage that the fungus achieved in oats. Leaf areas fixed eight, eleven, and seventeen days after inoculation showed no further development.

Discussion of experiments with *Puccinia triticina*

It seems clear from these experiments that *P. triticina* (in England) is not sharply specialised to wheat. Eriksson [8] found that rye could sometimes be infected with this rust, and Mehta [15], working in England, obtained successful infection on three out of twenty-one seedlings of rye inoculated. These authors were in agreement that rye was subject to "casual infection" by *P. triticina*.

Different types of reaction result when rye is inoculated with *P. triticina*. The phenomena encountered suggest a similarity to the "heterogeneous or X-reaction" described by Stakman and Levine [21] for the types of reaction observed on some wheat varieties inoculated with certain biologic forms of *P. graminis Tritici*.

A further indication that *P. triticina* is not closely specialised to wheat was obtained from Exps. Nos. 5, 9, 12 and 41 (Tables I and II). In these minute pustules were produced on barley.[1] Microscopic examination of inoculated areas removed during the course of Exp. No. 41 revealed infected zones similar to those of type D reaction in rye. Dead mesophyll cells were less numerous in barley, indicating that the reaction was less violent than in rye. The pustules which developed were small and aborted.

Oats was consistently immune to *P. triticina*. Flecking was observed in three out of fifteen inoculations, but no pustules developed. Microscopic examination showed that the rust frequently entered oats, but thereafter made little progress; only one small haustorium was found in the many entries which were examined.

One further point deserves comment. Experiments were carried out to determine whether a sojourn of the rust on rye and barley would increase its virulence on these respective hosts. Spores produced by successful infections on rye with *P. triticina* were used to inoculate seedlings of rye and wheat. The results showed that the virulence was not increased, since these inoculations produced only weak infections on rye accompanied by necrosis, whereas heavy crops of spores were produced on wheat in every trial. Rye was apparently more susceptible to *P. triticina* taken directly from wheat. On the one occasion when pustules on barley produced sufficient spores to be used as an inoculum, these were used to inoculate barley seedlings (Exp. No. 10). No infections resulted.

Section II. *Puccinia glumarum Tritici* Erikss.

P. glumarum Tritici is one of five specialised forms of *P. glumarum* described by Eriksson in 1894. Forms of yellow rust occur also on barley, rye, and various grasses. According to Eriksson, the rust on wheat is a specialised form for that host, and does not infect barley or rye. In the United States, however, Hungerford and Owens (12) found that *P. glumarum Tritici* would infect rye "moderately", barley "slightly", and forty-seven wild grasses. They found that oats did not become infected when inoculated with this form.

Mehta (15) showed the strict specialisation of *P. glumarum Tritici* to wheat; barley and rye were not infected by this form.

The histology of *P. glumarum Tritici* has been studied by Pole-Evans (17) and by Marryat (14), and in 1928 Allen published an account of the cytology of *P. glumarum* on *Bromus marginatus* and *Triticum vulgare*.

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[1] Prof. H. S. Jackson has informed me that *P. triticina* has been found in the United States, occurring naturally on a wild variety of barley.

Establishment of the Cultures

Norka wheat, a variety very susceptible to yellow rust, was used exclusively for the greenhouse cultivation of this rust. Plants of Norka wheat kept on the roof of the Botany School, Cambridge, became infected with yellow rust in October 1927. Successive transfers of the rust were made to Norka wheat in the greenhouse, and for eight months the culture was maintained. In the hot summer of 1928, however, the culture was lost at the end of June. Infected leaves of Little Joss wheat, found at the University Farm on June 30, 1929, provided spores from which another culture was established and maintained in the greenhouse for six months.

Experiments with *Puccinia glumarum Tritici*

Seedlings of Norka wheat, Grey Winter oats, rye (variety unknown), and Spratt Archer barley were inoculated with spores of *P. glumarum Tritici*.

The experiments and results are set out in Table III.

Table III. *Experiments with* Puccinia glumarum Tritici

Exp. No.	Date	Plants inoculated	Culture used	Results
1	May 21, 1928	Wheat Rye Barley Oats	G 4 from Norka	Flecking on wheat on 7th day. Pustules on wheat only on the 10th day. Brownish yellow streaks on barley 14th day, but no indication of infection on oats or rye
2	July 15, 1929	Wheat Rye Barley Oats	G 1 from Norka (new culture)	Flecking on wheat on 7th day. Very small pustules on wheat only on 12th day. No sign of infection on barley, oats or rye
3	Oct. 6, 1929	As in 1 and 2	G 3 from Norka	Moderately good infection on wheat after an incubation period of 3 weeks. No sign of infection on barley, oats, or rye
4	Oct. 30, 1929	As in 1 and 2	G 4 from Norka	As in Exp. No. 3 above
5	Nov. 26, 1929	As in 1 and 2	G 3 from Norka	As in Exp. No. 3 above

In Exps. Nos. 1 and 2, inoculated areas of wheat, rye, barley and oats were removed at intervals after inoculation and prepared for microscopic study. The remaining experiments, Nos. 3, 4 and 5, were carried out for macroscopic observation only.

It seemed clear from the macroscopic observations in the experiments of Table III, that yellow rust of wheat is closely specialised to that host. This was confirmed by the microscopic study of the inoculated plants.

Development of Puccinia glumarum *in wheat*

Within twenty-four hours many spores germinated and formed long germ tubes on the leaves. No entries were found until the second day, although Allen (6) found entries sixteen hours after inoculation; she noted, however, that entry might be delayed for several days. This was also found in my experiments, where new vesicles were found in the substomatal cavities as late as the seventh day. The fungus entered without forming an appressorium, as pointed out also by Pole-Evans (17), and the stomata of entry were not damaged. The germ tubes usually entered at one end of a stoma, but were occasionally found near the centre.

The prolonged initial developmental period of *P. glumarum* under certain conditions is well known. By the fourth day many infections showed no advance beyond the formation of the first haustorium from the infecting hypha; other infections, however, made considerable progress, and thick, non-septate hyphae with numerous nuclei were found among the mesophyll cells.

Leaf areas fixed on the seventh day showed a marked increase in mycelial development. (This coincides with the appearance of flecking on this host.) Hyphae were both branched and unbranched, and they were full of contents. The long, runner-like hyphae described by Allen (6) were frequently seen in leaf areas fixed on the seventh day.

By the tenth day the hyphae were narrower and their contents less dense. Haustoria at this time were mostly of the "hammerhead" type and were found in both epidermal and mesophyll cells. Small pustules had sometimes developed by this time; the epidermis was still unruptured over them, and the hyphae in the pustule regions were considerably drained or else quite empty.

On the fourteenth day numerous pustules had formed on both surfaces of the leaves, and the underlying mesophyll tissue was often almost completely obliterated by the profuse development of hyphae. These were empty and septate. Where the hyphae were less dense, haustoria, large and of various shapes, were present in the host cells. These completely replaced the "hammerhead" type, which were so common on the tenth day. The host cells were impoverished but still living.

Development of Puccinia glumarum Tritici *in rye*

No entries were found in rye until the fourteenth day after inoculation. Earlier material showed many spores of the inoculum on the surface of the leaves; some of these had germinated and formed long germ tubes, which had shrivelled, however, without entering.

In material fixed on the fourteenth day several entries were seen.

The fungus, however, had made little progress and was invariably dead. The guard cells were also dead and discoloured. Fig. 7 (fourteen-day material) shows one of these entries. The empty spore, somewhat shrivelled, lies near the stoma where the fungus entered. As usual with *P. glumarum*, entry was made at one end of the stoma. The guard cell seen in section is dead and discoloured, and closely applied to it is the vesicle *a*, typical of this rust, now empty. In this entry two large infecting hyphae, *b* and *c*, developed. Hypha *b*, soon after its formation, attacked and killed a mesophyll cell bordering on the substomatal cavity. The hypha is now misshapen and deeply stained. The empty haustorial mother cell *d* is seen outside the dead host cell, and it appears that the large haus-

Fig. 7. (×315.)

torium *e* coiled itself about the host nucleus *f*. Both haustorium and nucleus are dead and deeply stained, and in the cell the remains of a few chloroplasts are faintly visible. The hypha is considerably swollen behind the empty haustorial mother cell, a fact which suggests that some food from the host had passed back through the haustorial mother cell before death occurred. After this failure to establish contact with the host, hypha *b* put out a branch *g*, but no infection resulted. This branch *g* is dead and deeply stained like the rest of the fungus. The two host cells in contact with *g* are living and retain their normal appearance. An adjacent cell *h*, though not in contact with the fungus, is dead and deeply stained. The other infecting hypha *c* branched into two just before meeting the host cell *i*, which borders on the substomatal chamber. Both branches of *c* produced haustoria in this cell. It appears that these haustoria, *j* and *k*, arose without the usual formation of haustorial mother cells. Both haustoria are dead, and lie in contact with the nucleus of the dead host cell.

This entry represents the greatest progress made by *P. glumarum Tritici* in rye; the fungus was short-lived, and only a few host cells were killed.

Microscopic study showed that rye is immune to yellow rust of wheat. For some time after inoculation, although the spores ger-

minated on the leaves, they failed to effect entries. After this delay, however, entries were made, but these were not nearly so numerous as in wheat. Only slight progress was made after entry, the infecting hyphae producing at most one or two haustoria before death. On the rare occasions when this development was attained, a few host cells were killed. The relation between rye and *P. glumarum Tritici* was uncongenial.
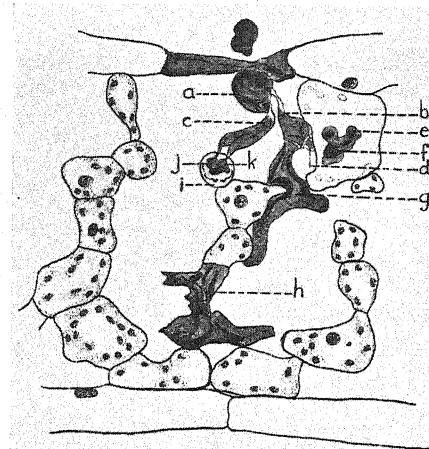
Development of Puccinia glumarum Tritici *in barley*

The fungus was first found in leaf areas of barley fixed on the seventh day. As in rye, the guard cells of the stomata of entry were always dead and discoloured. Entries were common in the seven-day material of barley; infecting hyphae had developed but no haustoria had been formed, and in all cases the fungus was dead.

A further stage of development in barley is seen in Fig. 8 (fourteen-day material). The guard cell is dead and the vesicle quite empty. As before, the fungus is now dead, but several host cells were affected before death occurred. Two infecting hyphae developed from the vesicle, *a* and *b* (hypha *b* has been broken in sectioning). Hypha *a* formed a large haustorium *d* in the mesophyll cell *c*, which is devoid of contents. The haustorium has a thick neck; its mother cell *e*, now empty, is closely applied to the wall of the invaded host cell. An adjacent mesophyll cell shows a distinct thickening of its wall. The other infecting hypha *b* extended further but did not produce a haustorium. It penetrated some distance into the leaf tissues, coming into contact with several mesophyll cells. These developed thickened walls where they touched the hypha, but they were still

Fig. 8. (× 315.)

living. Damage done by the fungus was accordingly slight, the area of tissue affected being small.

Other leaf areas of barley taken fourteen days after inoculation showed yellow streaks at this time. It was found that the rust had made considerably more progress in these areas. Thick intercellular hyphae were often found amongst the mesophyll cells, but haustoria were rare.

A section through one of these areas is drawn in Fig. 9 (fourteen-

day material). Hypha *a*, which still retains most of its contents, formed a haustorium at *c*, which lies in contact with the cell nucleus. The empty haustorial mother cell is closely applied to the wall of the invaded cell. Hypha *d* is dead and its contents deeply stained. Some host cells in contact with these hyphae are devoid of contents.
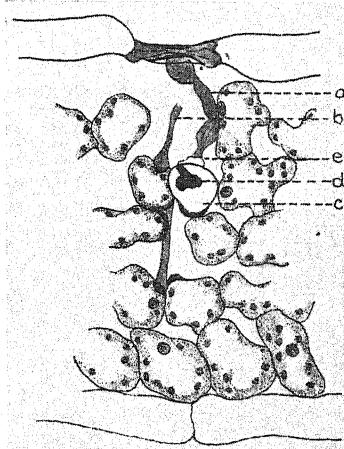
No extensive damage was done by the hyphae in these streaked leaf areas. At most, groups of five or six dead host cells were found. This was the most advanced stage reached by the fungus in barley.

Development of Puccinia glumarum Tritici *in oats*

Entries in oats were less numerous than in rye and barley. As in rye, no entry was seen until several days after inoculation. The guard cells of the stomata of entry were always killed, and the infecting hyphae quickly died.
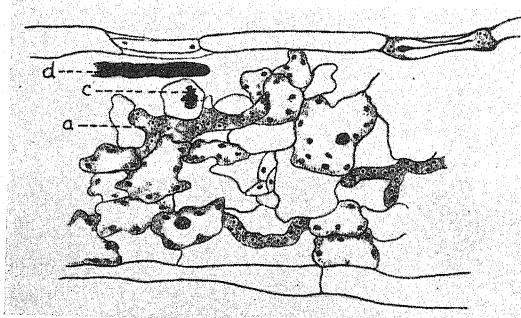
Fig. 9. (×315.)

DISCUSSION OF EXPERIMENTS WITH *PUCCINIA GLUMARUM TRITICI*

The development of yellow rust in Norka wheat, except for slight points, is in close agreement with the published accounts of Pole-Evans (17), Marrayat (14), and Allen (6). The "intracellular bodies" described by Allen were not found in the infected leaves of Norka. A congenial relation existed between this wheat and the rust; only in regions of heavy spore production were the host cells harmed.

Rye, barley and oats were immune from *P. glumarum Tritici*. Only in one experiment (No. 1) was there any outward sign of infection, some of the inoculated areas of barley becoming streaked.

In these streaked areas in barley the rust had produced thick intercellular hyphae in the mesophyll, but little damage was done to the leaf although some cells were killed and devoid of contents. The reaction between barley and the rust was not violent, and quite

unlike that in the immune wheats such as Einkorn or American Club, studied by Marryat. Usually, the rust made little progress in barley after entry. No relation was established with the mesophyll cells in some infections, while in others slight growth took place after the formation of the first haustorium. The walls of mesophyll cells were always considerably thickened where they came in contact with hyphae.

The rust succeeded also in entering rye and oats; as in barley, the guard cells of the stomata of entry were killed. In rye and oats, however, the mycelia were always short-lived. In rye there was no progress beyond the occasional formation of haustoria, while in oats no haustoria were seen. Damage done to the tissues of these plants was negligible, since only a small number of dead mesophyll cells were found near the points of entry.

Section III.
Puccinia anomala Rostrup = *Puccinia simplex* Erikss. & Henn.

Mehta (15) inoculated wheat, rye, barley and *Agropyron repens* with brown rust of barley. He found that the rust attacked only barley. In studying the host specialisation of *Puccinia anomala* Mains (13), in extensive inoculations of grasses, succeeded in infecting only five closely related species of *Hordeum*. Pole-Evans (17) described briefly the histology of this rust on barley.

ESTABLISHMENT OF THE CULTURE

The culture was established on Spratt Archer barley in the greenhouse from spores collected on the University Farm, Cambridge, on May 11, 1928. The culture was maintained on this variety for nearly two years.

EXPERIMENTS WITH *PUCCINIA ANOMALA*

Spores of this rust were used to inoculate Spratt Archer barley, Grey Winter oats, Wilhelmina wheat, and rye of unknown variety. The experiments are set out in Table IV.

In Exps. Nos. 1 and 4 inoculated leaf areas of all plants were fixed at one, two, three, six and nine days, respectively, after inoculation. In addition, areas of wheat and barley from Exps. Nos. 2 and 5 were fixed fourteen days after inoculation, although these experiments were originally intended for macroscopic observation only. In the other experiments the inoculated plants were kept under observation for one month, no leaf areas being removed.

Table IV. *Experiments with* Puccinia anomala

Exp. No.	Date	Plants inoculated	Culture used	Results
1	July 10, 1928	Barley Wheat Oats Rye	G 3 from barley	Pustules only on barley, after 7 days. No sign of infection on the other plants
2	Sept. 5, 1929	As in 1	G 2 from barley	Faint flecking on barley and wheat after 3 days. Numerous pustules on barley only on 6th day. Wheat definitely flecked after 21 days, but no sign of infection on rye and oats
3	Sept. 9, 1929	Barley Wheat	G 2 from barley	Numerous pustules on barley after 8 days. No sign of infection on wheat at end of 30 days
4	Sept. 17, 1929	Barley Wheat Oats Rye	G 3 from barley	Numerous pustules on barley after 8 days. No infection of the other plants at the end of 30 days
5	Sept. 30, 1929	As in 4	G 4 from barley	Numerous pustules on barley after 10 days. Faint flecks on wheat on 7th day; but no further infection after 30 days. No infection on oats or rye
6	Oct. 15, 1929	As in 4	G 5 from barley	Flecks on barley and wheat on 3rd day. Numerous pustules on barley only, on 8th day. No further infection on wheat, and no sign of infection on rye and oats after 30 days
7	Oct. 28, 1929	As in 4	G 6 from barley	Flecks on barley and wheat on 8th day. Pustules on barley only, on 11th day. No further infection on wheat, and no signs of infection on rye and oats after 30 days
8	Nov. 16, 1929	As in 4	G 7 from barley	On 11th day—numerous pustules on barley without previous flecking, but wheat flecked at this time. No further infection on wheat, and no signs of infection on oats or rye after 30 days
9	Nov. 23, 1929	Barley Wheat	G 7 from barley	Fair infection on barley, pustules appearing on 17th day. No sign of infection on wheat after 30 days

Development of Puccinia anomala *in barley*

By the end of the first day most of the spores had germinated and several entries were found. Germ tubes were occasionally seen which had branched into two on the leaf surfaces. Appressoria were formed over the stomata, and the contents of these passed into narrow elongated vesicles in the substomatal cavities, lying parallel to the guard cells. Infecting hyphae were not seen until the second day; these developed from one or both ends of the long vesicles.

By the end of the third day the fungus had made considerable progress. Delicate intercellular hyphae ramified in the host tissue, and numerous haustoria were present in the mesophyll cells. The infected zones were more or less local, as they were in material fixed six days after inoculation. Occasionally long, runner-like hyphae passed from one infected zone to another, often encountering as many as twelve cells before forming a haustorium. Some pieces of barley

leaf fixed on the sixth day showed various stages in reproductive activity. Wefts of mycelium in preparation for pustule formation were found under the epidermis, and pustules were sometimes present on both surfaces of the leaves. Hyphae in the pustule regions were empty and septate, and numerous uninucleate haustoria, more or less drained, lay in the host cells. The host cells retained their living contents. Throughout the development of the rust the relation was congenial.

Development of Puccinia anomala *in wheat*

The leaf areas of wheat fixed at intervals in Exps. Nos. 1 and 4 showed no entry of the fungus, in spite of the fact that many of these areas were flecked at the time of fixation. It seems clear that flecking here was not due to the fungus. Many spores had germinated on the leaves, but the germ tubes shrivelled without forming appressoria.

In Exps. Nos. 2 and 5, however, in which flecking of wheat was also observed, areas removed fourteen days after inoculation showed entry of the fungus. Where entry had occurred the guard cells were always dead. Sometimes no infecting hyphae were developed from the vesicles, but frequently one or two were found. The vesicles and infecting hyphae were always quite empty and much shrivelled. Only once was a small haustorium seen.

However, rather large groups of cells were sometimes killed around points of entry. Mycelium could not be seen in these dead areas, nor could haustoria be distinguished, as the cells were shrunken and deeply stained. The empty vesicles found in the substomatal chambers alone suggested that the damage to the leaf tissue was caused by the fungus.

Development of Puccinia anomala *in oats*

Germinating spores were seen on the surface of the leaves at all times of fixation, that is up to the ninth day after inoculation, but only occasionally was entry achieved. When this occurred the guard cells were killed. No infecting hyphae developed and the mesophyll cells around the vesicles appeared normal.

Development of Puccinia anomala *in rye*

A few entries were observed on the second day after inoculation. These were similar to entries found in oats at this time. The guard cells of the stomata of entry were always killed. No infecting hyphae developed from the vesicles, and the surrounding mesophyll tissue showed no signs of disturbance. No further progress was made in rye.

DISCUSSION OF EXPERIMENTS WITH *PUCCINIA ANOMALA*

The experiments indicate a close specialisation of the rust to barley, a congenial relation being maintained between barley and the rust throughout its development.

P. anomala occasionally entered wheat, oats and rye, and when this occurred the guard cells of the stomata of entry were always killed. Only wheat, among these plants, showed flecking, but this also occurred on some leaves in which entries had not been made. A single small haustorium was found in wheat, and here the invaded host cell was not killed. Mesophyll cells in contact with infecting hyphae had thickened walls. In some entries in wheat it was clear that a violent reaction had taken place resulting in the death of groups of mesophyll cells, in addition to the guard cells. Hyphae could not be seen amongst these dead tissues surrounding such entries. The damage done to wheat was never extensive.

Entries were fewer in oats and rye than in wheat. No infecting hyphae developed, and no damage, apart from the death of guard cells, resulted. Not a single dead mesophyll cell was seen in oats or rye.

Section IV. *Puccinia coronata* Corda

In 1922 Hoerner carried out extensive inoculation experiments on barley, rye, wheat, and many grasses, using crown rust of oats from different localities. The results showed that crown rust of oats in the United States has an extensive host range under greenhouse conditions, since, in addition to successful infections of many varieties of oats, a number of grasses and three varieties of barley became infected. Flecking was observed on *Lolium italicum* (but not on *L. perenne*), and also on rye and wheat, but no pustules were formed on these plants.

A brief account of the histology of this rust was given by Pole-Evans[17]. Ruttle and Fraser[18] published a detailed account of the cytology of *Puccinia coronata* on Banner oats, a susceptible variety, and on Cowra 35, a variety which showed different degrees of resistance.

ESTABLISHMENT OF THE UREDOSPORE CULTURE

Grey Winter oats were used as the host for the greenhouse cultivation of the rust. The original source of the rust was from infected oats found at the University Farm, Cambridge, on November 14, 1927. The culture was maintained in the greenhouse for two years.

PART A. INOCULATION WITH UREDOSPORES OF *PUCCINIA CORONATA*

On May 29, 1928, seedlings of the following plants were inoculated with uredospores: Grey Winter oats, Wilhelmina wheat, Spratt Archer barley, rye, *Lolium perenne* and *L. italicum*.

Marked leaf areas from all these plants were removed one, two, three, five, seven, ten and fourteen days, respectively, after inoculation, and prepared for microscopic study.

Macroscopic observations of the inoculated plants

Flecks appeared only on oats and wheat on the fourth day. By the sixth day barley showed signs of flecking, but these were faint, compared with those on oats and wheat, those on wheat being most distinct. By the tenth day oats, wheat and barley were definitely flecked, but there were no signs of flecking on the other plants. On the fourteenth day, when the final fixations were made, pustules were numerous on oats.

Inoculated leaf areas, which had not been removed during the course of the experiment, were kept under observation for one month. No pustules developed on wheat or barley, and there was no sign of infection on rye, *Lolium perenne*, or *L. italicum*.
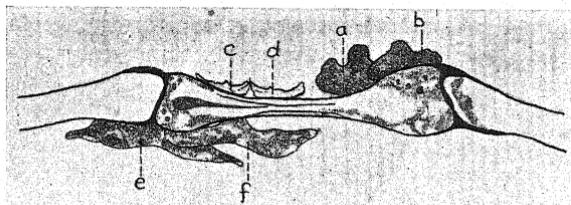
Fig. 10. (×630.)

Development of Puccinia coronata *in oats* (*from uredospores*)

The spores germinated by the end of the first day and formed appressoria over the stomata. The appressoria were either regular in outline or lobed as described by Ruttle and Fraser (18). Stomata of entry were not damaged. The appressorial contents had mostly passed into vesicles in the substomatal chambers, and by the end of the first day these had already assumed the elongate form characteristic of this rust. It was not unusual to find two or more vesicles in one substomatal cavity, as, for example, in Fig. 10 (*e, f*) (twenty-four-hour material), which shows four appressoria.

The rust made little progress during the next four days, though sometimes long, delicate infecting hyphae developed from one or both arms of the vesicles, leaving the latter empty. A median septum could often be seen in the vesicle. The infecting hyphae sometimes penetrated for some distance into the host tissue before forming a haustorium, though often the first host cell encountered was invaded.

At the end of the first week no extensive mycelium had developed, only a few delicate hyphae being observed among the mesophyll cells. By the tenth day, however, the stages preparatory to pustule formation were observed. Hyphae, dense with contents, were now massed

below the upper and lower epidermis, the hyphae in the central parts of the leaves being almost empty. Haustoria in these regions were drained; they were seen in both mesophyll and epidermal cells. By the fourteenth day numerous sporing pustules had formed on both surfaces of the leaves.

Throughout the development of the rust its relation with the host was completely congenial. The rate of development of *P. coronata* in Grey Winter oats in this experiment was considerably slower than its development in Banner oats described by Ruttle and Fraser [18].

Development of Puccinia coronata *in wheat, rye, barley,* Lolium perenne *and* Lolium italicum

The stage of development reached by the rust in all these plants was approximately the same.

By the end of the first day many spores had germinated, and formed numerous appressoria over the stomata; the appressoria were usually
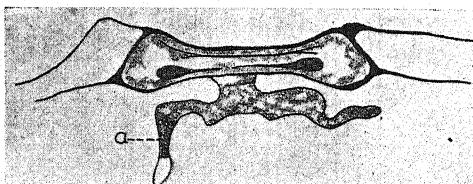
Fig. 11. (× 630.)

empty, having formed large vesicles in the substomatal cavities. The vesicles were of the typical elongate form as found in oats, and infecting hyphae (*a*) had already begun to develop in many entries. This condition is shown in Fig. 11 (for rye).

Similar entries were also common in barley, *Lolium perenne* and *L. italicum* fixed at the same time. The stomata entered by the fungus were not damaged at this stage.

After entry, the fungus made little progress. Later fixations showed that the vesicles with their short infecting hyphae had shrivelled in the substomatal cavities before reaching the mesophyll. This was common in all leaf areas fixed after the fifth day, and the guard cells of the stomata of entry had been killed. Only occasionally in these plants did infecting hyphae reach the mesophyll, when a few cells were either killed or their walls were thickened if in contact with the hyphae.

This is shown in Fig. 12, drawn from wheat fixed on the seventh day. Three germ tubes reached the stoma, but only one of these, *a*, entered, leaving outside the remnants of the appressorium. The other

two appressoria, *b* and *c*, appear to be drying up. The vesicle which developed from *a* produced two infecting hyphae, *d* and *e*, but no haustoria were formed. Hypha *e* put out several branches which passed between the mesophyll cells. No cells were killed, but their walls were often thickened where in contact with the hyphae. The fungus itself was somewhat shrivelled.

Only a single haustorium was observed in these plants. This was found in a leaf area of barley fixed on the seventh day. This entry was the furthest development of *Puccinia coronata* in barley, and in forming one small haustorium, it exceeded the progress of the rust in wheat, rye, *Lolium perenne* and *L. italicum*. The damage done to the leaf tissue was always negligible.
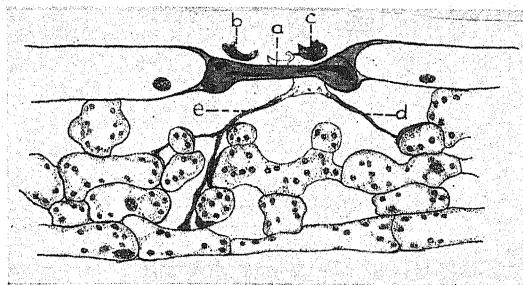
Fig. 12. (× 315.)

DISCUSSION OF RESULTS WITH UREDOSPORES OF *PUCCINIA CORONATA* CORDA

The microscopic study of this rust in oats showed that in its normal development there was a congenial relation between host and parasite. The rust gained entry into wheat, barley, rye, *Lolium perenne* and *L. italicum*, without at first damaging the stomata. Its subsequent progress was extremely limited, and only once did an infecting hypha produce a haustorium. This occurred in barley. Sometimes a few dead mesophyll cells were seen in contact with the infecting hyphae. Damage done to these plants was negligible and they were immune to attack from *Puccinia coronata* Corda.

PART B. INOCULATIONS WITH AECIDIOSPORES FROM *RHAMNUS CATHARTICUS* AND *RHAMNUS FRANGULA*

In the experiments with aecidiospores from *R. catharticus* and *R. Frangula* the method of inoculation was the same as in the previous experiments.

Infected bushes of both species of *Rhamnus* were found near Cambridge. Fresh spores were used to inoculate Grey Winter oats, Wilhelmina wheat, Spratt Archer barley, rye (unknown variety), *Lolium perenne* and *L. italicum*.

For each experiment a fresh supply of aecidiospores was obtained from the field. The spores invariably showed 100 per cent. germination in tap water when used for inoculation.

The experiments are summarised in Table V.

Table V. *Experiments with aecidiospores from* Rhamnus

Exp. No.	Date	Plants inoculated	Source of aecidiospores	Results
1	June 11, 1929	Oats Wheat Barley Rye *L. perenne* *L. italicum*	*R. catharticus*	Faint flecks on wheat and rye 6 days after inoculation. After 30 days no sign of infection of the other plants and no further development in wheat and rye; no sign of pustules
2	June 18, 1929	As above	*R. catharticus*	As in Exp. No. 1
3	July 4, 1929	As above	*R. Frangula*	No flecking on any of the plants. No sign of infection at the end of 30 days
4	July 17, 1929	As above	*R. catharticus*	Faint flecks on wheat on the 6th day and on oats on the 7th. One month after inoculation some leaves of oats and wheat still showed flecking but no pustules. No sign of infection on the other plants

In Exps. Nos. 1 and 2 marked leaf areas were removed at intervals from all the inoculated plants and prepared for microscopic study. The times of fixation were as follows: in the former one, three, five, seven and fifteen days after inoculation; in the latter two, three, seven, ten and fifteen days after inoculation.

The results of these experiments were unexpected, in that no pustules were produced on oats by aecidiospores from *Rhamnus catharticus*. Further consideration of these observations will be postponed until the discussion at the end of this section.

Microscopic observations on plants inoculated with aecidiospores from *Rhamnus catharticus*

Examination of the inoculated leaf areas showed that entries resulting from germinating aecidiospores are essentially the same as those resulting from the uredospores of *Puccinia coronata* Corda, described above. So far as is known, this study constitutes the first detailed demonstration of the method by which aecidiospores effect entry into the plant.

Although many spores germinated during the first twenty-four hours, germinating spores were observed on leaves as late as two

weeks after inoculation. The fungi entered the leaves of all plants inoculated. Appressoria were formed over the stomata; these were always smooth in outline, and never lobed as were often the appressoria which developed from uredospores of *P. coronata*. The vesicles, however, were almost identical with those which developed from the uredospores. Although the progress made after entry was slight, it varied in the different plants which were inoculated.

Development of the fungus in oats

Many aecidiospores germinated during the first twenty-four hours and formed appressoria over the stomata. Vesicles were found in the substomatal cavities, but no infecting hyphae had developed. The stomata of entry were not damaged.
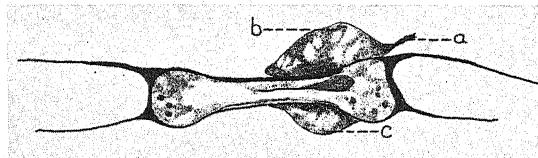
Fig. 13. (×630.)
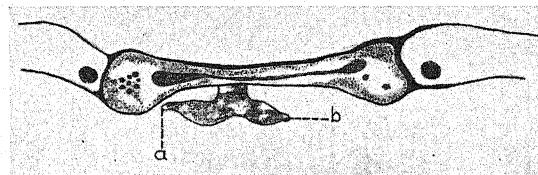
Fig. 14. (×630.)

The method of entry is shown in Figs. 13 and 14, drawn from twenty-four-hour material. In Fig. 13 a vesicle (*c*) is just being formed, the large appressorium (*b*) over the stoma still retaining most of its contents. Part of the shrivelled germ tube (*a*) is still attached to the appressorium.

The vesicle shown in Fig. 14 is fully developed and has the characteristic shape of the vesicle of crown rust of oats. Rudimentary infecting hyphae (*a, b*) can be seen, one at each arm of the vesicle.

In five-day material the fungus was still at the same stage, although the vesicles generally showed signs of shrivelling. Occasionally infecting hyphae had developed and had reached mesophyll cells, but the vesicles were always empty and shrunken and the infecting hyphae considerably shrivelled. No haustoria had developed. One

of these entries is shown in Fig. 15. Here the guard cells are still living but are somewhat discoloured. The empty germ tube (*a*) and appressorium (*b*) are seen outside and the shrunken vesicle (*c*) in the substomatal chamber. Only one infecting hypha (*d*) has developed. This reached a mesophyll cell (*e*), which is dead and deeply stained. It is impossible to distinguish the contents, and therefore it is not known whether a haustorium was formed.

Similar entries were found in leaf areas fixed on the tenth and fifteenth day after inoculation, but no progress beyond the stage shown in Fig. 15 had been made. In all the leaf areas of oats not a single haustorium was seen and there was no trace of an intercellular mycelium.
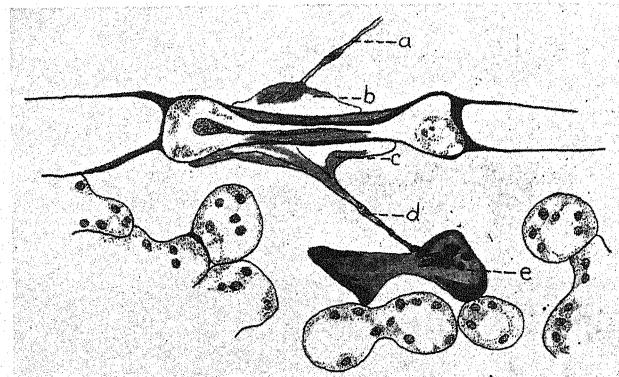
Fig. 15. (× 630.)

Development of the fungus in Lolium perenne and Lolium italicum

The spores germinated, forming appressoria and vesicles. These were numerous in both species of *Lolium* by the end of the first day and were similar to those described for oats. No further development occurred after entry. Leaf areas fixed on the fifteenth day showed empty, shrivelled vesicles but no infecting hyphae, although rudiments of these were sometimes apparent.

Development of the fungus in wheat

Vesicles were quite numerous in wheat by the end of the first day. Frequently two or more were found in the same cavity, and no damage to the stomata resulted. No infecting hyphae developed beyond the rudimentary stage, as in *Lolium perenne* and *L. italicum*.

Inoculated areas of wheat which showed flecking at the time of fixation revealed no development of the fungus after entry. The

formation of vesicles marked the maximum development in wheat. Vesicles were found on the fifteenth day after inoculation, but at this time they were always shrivelled.

Development of the fungus in barley

Leaf areas of barley showed numerous entries; frequently as many as four vesicles were found in one substomatal cavity.

An unusual entry found in barley is drawn in Fig. 16 (five-day material). The remains of two appressoria (*a, b*) are seen over the stoma. Separate entries were made, but these appear to have fused
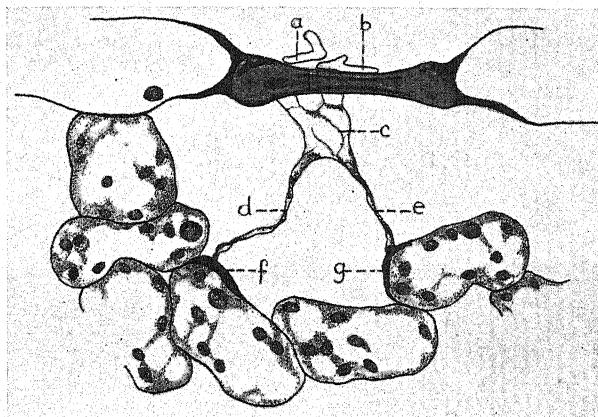
Fig. 16. (× 630.)

to form a large single vesicle (*c*) in the cavity. This is now empty and somewhat shrivelled. Two infecting hyphae (*d, e*) were produced, both of which reached the mesophyll but did not form haustoria. The walls of the mesophyll cells are thickened (*f, g*) where they are in contact with the hyphae, but both cells are living.

The furthest development of the fungus in barley was seen in a five-day fixation in which an infecting hypha formed a large haustorium in a mesophyll cell. No further development took place. This was the only haustorium seen in barley. There was no trace of an intercellular mycelium in barley.

Vesicles were found as late as the fifteenth day, the guard cells of the stomata of entry being usually dead. The vesicles at this time were either empty or completely shrivelled.

Development of the fungus in rye

Entries were common in rye by the end of the first day; these were similar to those described in oats. As late as the fifteenth day, however, germinating spores were still seen on the leaves.

Rye only, of all the plants inoculated with aecidiospores, showed traces of an intercellular mycelium. This was found in several areas fixed on the fifteenth day. The mycelium was scanty and consisted of only a few meagre hyphae. There were no signs of the entries from which the mycelia had developed, except that collapsed stomata were found in the infected regions. Large haustoria were seen in some cells, the latter being usually empty. These haustoria were of distinctive
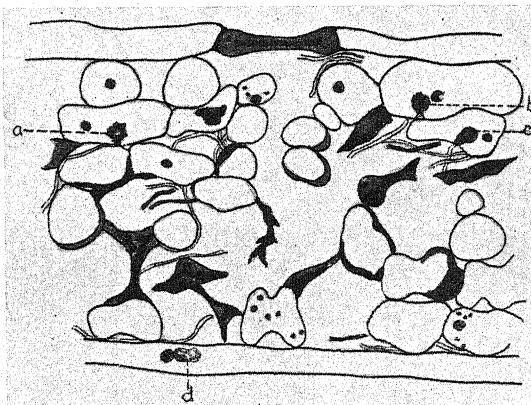
Fig. 17. (×315.)

type with thick necks and enclosed in striated sheaths of irregular margin. Some haustoria were transparent, with deeply stained sheaths, while others were deeply stained and the sheaths were clear, colourless and plainly striated. Haustoria similar to these found in rye have been described by Allen (2), occurring in infections of *Puccinia graminis Tritici* on Mindum wheat, a resistant variety.

Fig. 17 (fifteen-day material) is drawn from a section through one of these infected regions in rye in which an intercellular mycelium had developed. Most of the cells are dead and empty; in some the cell walls are very much thickened, while other cells have collapsed and are deeply stained. The hyphae and haustoria are dead. Haustoria are present in the mesophyll cells at *a*, *b* and *c*. These are stained in different ways and show the characteristic thick necks. Only haustorium *d*, which is in contact with the host nucleus, appears to

be living. In such infections there was an antagonistic reaction be-
tween rye and the fungus.

<div align="center">

DISCUSSION OF INOCULATIONS WITH AECIDIOSPORES
FROM *RHAMNUS* SPP.

</div>

The three experiments outlined in Table V show that the aecidio-
spores from *R. catharticus* failed to produce pustules on any of the
plants inoculated, although flecking occurred on wheat and rye in
two of the experiments (Nos. 1 and 2), and on wheat, rye and oats
in the other experiment (No. 4). In the experiment (No. 3) with
aecidiospores from *R. Frangula* there were no signs of infection on any
of the inoculated plants.

The microscopic study, which was restricted to plants inoculated
with aecidiospores from *R. catharticus*, has shown that the failure of
the fungus to produce successful infection was not due to failure to
make entry, since entries were numerous in all these plants.

Although the appressoria formed by the germinating aecidiospores
were always smooth in outline, and never lobed as were some appres-
soria from germinating uredospores of crown rust of oats, the vesicles
which developed had the characteristic form peculiar to *Puccinia
coronata* Corda.

The microscopic study showed, however, that no true infection of
oats resulted from inoculation with aecidiospores from *Rhamnus cathar-
ticus*. Entries were made and a few infecting hyphae developed, but
no haustoria were formed.

In wheat, *Lolium perenne* and *L. italicum* the progress of the fungus
was similarly restricted, no more development being made than in
oats. It seems, therefore, that the flecks seen on wheat and oats were
not due to the fungus.

Although barley showed no flecking, the fungus made slightly
more progress in this plant than in oats and wheat. The development
of infecting hyphae was rather more frequent, and in one entry a
haustorium was formed in a mesophyll cell. There was, however, no
further development.

Only in rye did the fungus develop so far as to produce an inter-
cellular mycelium. The mycelium was scanty and it was always clear
that there was an antagonistic relation between rye and the fungus,
since the hyphae and most of the haustoria were dead, as well as
many of the mesophyll cells in the infected zones.

All the plants inoculated were immune to aecidiospores obtained
from *Rhamnus catharticus*. It is evident, therefore, that the rust was
not the aecidial stage of the form of *Puccinia coronata* Corda, which
was cultivated on Grey Winter oats in the greenhouse. It doubtless
belonged to one of the many other physiologic forms of *P. coronata*.

Section V. *Puccinia graminis Secalis* Erikss.

P. graminis Secalis is one of six specialised forms of black rust recognised by Eriksson (7). According to him, this rust attacks rye, barley, *Agropyron repens* (couch-grass), and other grasses in Sweden, but not wheat or oats.

Stakman and Piemeisel (23) found that *Puccinia graminis Secalis* from *Agropyron repens* infected rye, barley, *A. repens*, and some other grasses, but oats and wheat were rarely infected. Mehta (15) was able to infect rye, barley, *A. repens*, and one variety of wheat (Red Sudan), but not oats.

Microscopic studies of *Puccinia graminis* have been confined almost exclusively to *P. graminis Tritici*, the black rust of wheat. A short account of the histology of *P. graminis Tritici* was published by Pole-Evans (17). Stakman (19) studied the histology of this rust on a susceptible variety of wheat (Minnesota No. 163) and on a resistant variety (Khapli). Further, he (20) made microscopic studies of oats inoculated with *P. graminis Tritici*, wheat inoculated with *P. graminis Avenae*, oats inoculated with *P. graminis Hordei*, and rye, wheat and barley inoculated with *P. graminis* from *Dactylis glomerata*.

There remain to be mentioned in connection with *Puccinia graminis Tritici* the study by Newton (16) of the development of the rust in a susceptible and a resistant variety of wheat, and the cytological studies by Allen (1, 2, 3).

ESTABLISHMENT OF THE CULTURE ON *AGROPYRON REPENS*

Uredospores were collected at Cambridge and greenhouse cultures were established on rye and couch-grass.

For some experiments uredospores for inoculation were taken directly from couch-grass out of doors, but for the later experiments they were obtained from the greenhouse cultures.

EXPERIMENTS WITH *PUCCINIA GRAMINIS SECALIS*

The plants inoculated with this form of black rust were as follows: *Agropyron repens*, rye (unknown variety), Spratt Archer barley, Wilhelmina and Norka wheats, and Grey Winter oats.

The experiments with *Puccinia graminis Secalis* are given in Table VI.

In Exp. 4 marked leaf areas were removed at intervals and prepared for microscopic study; the fixations were made one, three, five, seven and ten days after inoculation. In the remaining six experiments the plants were kept under observation for one month.

The data in the last column of the table may be summarised as follows:

Couch-grass. In five out of the seven experiments medium to heavy infections resulted; in one experiment there was a weak infection, and in one experiment no infection. Out of a total of sixty-nine plants inoculated (omitting Exp. No. 4) thirty-nine produced pustules.

Table VI. *Experiments with* Puccinia graminis Secalis

Exp. No.	Date	Plants inoculated	Culture used	Results
1	June 6, 1928	Couch-grass Rye Barley Wil. wheat Oats	From couch-grass in open	Couch-grass 9/12,* fair infection Rye 8/10, fair infection No sign of infection on: Barley 0/10 Wheat 0/10 Oats 0/10
2	Oct. 3, 1928	As in 1	From couch-grass in open	Couch-grass 0/17, flecking Rye 6/12, weak infection Barley 0/15, flecking Wheat 0/14 Oats 0/12
3	July 23, 1929	As in 1	G 1 from rye (greenhouse culture)	Couch-grass 10/10, very good infection Rye 10/10, very good infection Barley 0/10 Wheat 0/10 Rye 0/10
4	Aug. 25, 1929	Couch-grass Rye Barley Wil. wheat Norka wheat Oats	G 2 from couch-grass (greenhouse culture)	Areas removed from plants and fixed. There were numerous pustules on rye on 7th day and on couch-grass on 10th. Weak infection on barley after 21 days. No sign of infection on Wil. wheat, Norka wheat, or oats
5	Aug. 25, 1929	As in 4	G 3 from rye (greenhouse culture)	Couch-grass 10/10, excellent infection Rye 10/10, excellent infection Barley 2/10, very weak (after 21 days) Wil. wheat 1/10, very weak Norka wheat 0/10 Oats 0/10
6	Sept. 6, 1929	Couch-grass Rye Barley Wil. wheat Oats	G 4 from rye (greenhouse culture)	Couch-grass 8/10, good infection Rye 11/11, excellent infection Barley 0/10 Wil. wheat 0/9 Oats 0/7
7	Sept. 29, 1929	Couch-grass Rye Barley Wil. wheat Oats	G 5 from rye (greenhouse culture)	Couch-grass 2/10, weak infection Rye 3/10, weak infection Barley 0/10 Wil. wheat 0/10 Oats 0/10

* The denominator of the fraction represents the number of plants inoculated, the numerator the number which produced pustules.

Rye. Medium to heavy infections resulted in five out of the seven experiments, and weak infections in the other two. Out of a total of sixty-three plants inoculated (omitting Exp. No. 4) forty-eight produced pustules.

Barley. Very weak infections on barley were observed in two experiments (Nos. 4 and 5), and flecking in one experiment (No. 2). There was no sign of infection in the other experiments. Out of a total of sixty-five plants inoculated (omitting Exp. No. 4) only two produced pustules.

Wilhelmina wheat. Out of a total of seventy-three plants inoculated in the seven experiments, only a single plant (in Exp. No. 5) produced pustules, and these were few and minute. *Norka wheat* and *oats* were consistently immune.

These results are in agreement with the observations of Mehta (15), who found that couch-grass and rye were favourable hosts for *P. graminis Secalis*, and that Spratt Archer barley showed only weak infections. Mehta, and other workers, however, obtained good infections on other varieties of barley with *P. graminis Secalis*. Mehta also obtained weak infections on one variety of wheat, as was observed in my experiments with one plant of Wilhelmina wheat. Various workers have found that oats is consistently immune to this form of black rust.

MICROSCOPIC OBSERVATIONS OF PLANTS INOCULATED WITH *PUCCINIA GRAMINIS SECALIS*

Development of Puccinia graminis Secalis *in* Agropyron repens

Under the conditions of the experiment the rust made little progress in couch-grass during the first five days. By the end of the first day numerous appressoria had been formed over the stomata but only about 1 per cent. had formed vesicles and no infecting hyphae were seen at this time. Even on the third and fifth days comparatively few entries were found although appressoria were still numerous over the stomata. Usually, whether these stomata were penetrated or not, the guard cells were dead, and had lost their affinity for the diamant fuchsin stain. Stomata similar to these were also found by Allen (5, 3) in infections of wheat with *P. graminis Tritici*.

Sometimes guard cells were seen in which part of the protoplast was normally stained and part seemed dead and shrunken. This condition was seen only sometimes where the fungus had entered, as shown for example in Fig. 18 (seven-day material). The shrivelled germ tube (*a*) and appressorium (*b*) are seen outside. The fungus entered at one end of the stoma, forming a large vesicle (*c*). A single infecting hypha (*d*) was produced which ran more or less parallel to the leaf surface, and gave rise to a large haustorium (*e*) in the epidermal cell adjacent to the stoma of entry. The part of the guard cell nearest the haustorium is dead and shrunken (*f*), whereas the end where the fungus entered is apparently undamaged. The formation

of the first haustorium in an epidermal cell as in this entry was found to be general in infections with *P. graminis Secalis*.

From the seventh to the tenth day all stages of reproductive activity could be seen. When the final fixations were made (ten days after inoculation) numerous pustules had been formed on both surfaces of the leaves. Most of the intercellular hyphae in the pustule regions were quite empty, and were frequently septate. They were so densely packed that the outlines of some of the cells were completely obscured. Haustoria were rare in host cells immediately below pustules, and when present they were drained.

Apart from the death of guard cells, the relation between couch-grass and the rust throughout its development was congenial.
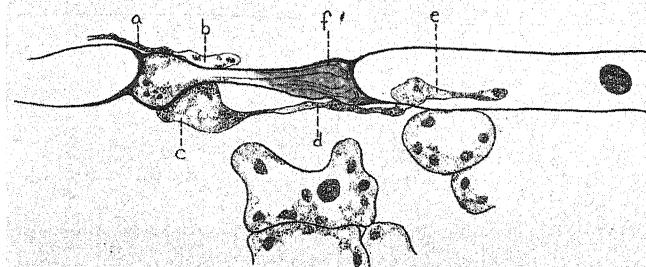
Fig. 18. (× 630.)

Development of Puccinia graminis Secalis *in rye*

In rye numerous appressoria were seen over the stomata twenty-four hours after inoculation, and although few entries had been made, they exceeded in number those found in couch-grass at the same time. The guard cells of the stomata of entry were usually dead and dis-coloured as in couch-grass. Approximately 5 per cent. of the appres-soria had produced vesicles in rye by the end of the first day, but no infecting hyphae had been formed.

The fungus advanced more rapidly in rye than in couch-grass. By the third day long infecting hyphae had developed, and many of these had produced haustoria. The infecting hyphae always took a course parallel to the leaf surface, and the first haustorium was formed in the epidermal cell adjacent to the stoma of entry.

By the fifth day an intercellular mycelium was well developed, and haustoria were numerous in both mesophyll and epidermal cells. Leaf areas fixed at this time showed that vesicles were still being formed in the substomatal cavities.

On the seventh day numerous pustules were found on both surfaces

of the leaves. The mycelium was dense in the mesophyll tissue under-
lying the pustules.

As in couch-grass, the relation between host and rust was con-
genial.

Development of Puccinia graminis Secalis *in barley*

The early development of the rust in barley was similar to that in
rye. Appressoria were abundant by the end of the first day, but the
fungus had rarely entered the leaves. The fungus had already
shrivelled in one or two of the entries.

New vesicles were still being formed on the third day. No haus-
toria were seen in barley until the fifth day, and they were compara-
tively rare. As always in this rust, the first haustorium was formed
in an epidermal cell adjacent to the stoma of entry. Haustoria were
smaller than those in couch-grass and rye.

Leaf areas fixed seven and ten days after inoculation still showed
no trace of an intercellular mycelium. Appressoria were still seen
over the stomata, and occasionally empty vesicles were found in the
substomatal cavities. The guard cells of the entered stomata were
invariably dead and discoloured. It was apparent that barley was
not a favourable host for *P. graminis Secalis* under the conditions of
the experiment.

No material was fixed after the tenth day. In this particular experi-
ment (No. 4, Table VI), a few minute pustules appeared on some
leaves twenty-one days after inoculation. It is evident therefore that
some entries resulted in the establishment of an intercellular my-
celium, but since no material was fixed nothing can be said concerning
the host-parasite relation in these infections which produced minute
pustules.

Development of Puccinia graminis Secalis *in wheat*

In Wilhelmina wheat, only one small vesicle was seen in the leaf
areas fixed twenty-four hours after inoculation, although many ap-
pressoria were seen over the stomata. The guard cells were always
dead.

The rust made little progress during the next two days, and entries
were rare. On the fifth day vesicles were more common, but they
were usually empty. Some had given rise to infecting hyphae but
these were poorly developed and none had formed haustoria.

The seven- and ten-day fixations showed no further development
of the fungus. Not a single haustorium was found in any of the leaf
areas.

Apart from the dead guard cells where the fungus was seen, there
was no damage to the leaf tissues, the fungus making no progress
after entry.

The development of the rust in Norka wheat was similar to that in Wilhelmina wheat. A few entries were seen, but no haustoria were formed.

In this particular experiment (No. 4, Table VI) neither variety of wheat became infected, but it should be pointed out that in one of the other experiments (No. 6, Table VI) a weak infection was obtained on Wilhelmina wheat.

Development of Puccinia graminis Secalis *in oats*

Appressoria were formed over the stomata, but few entries were made in oats. The guard cells of stomata bearing appressoria were always dead, being discoloured whether the fungus entered or not.

A few vesicles were found twenty-four hours after inoculation, but no infecting hyphae had developed. Newly formed vesicles were seen in the later fixations, occasionally even as late as the tenth day, but neither infecting hyphae nor haustoria were seen in oats.

Apart from the killed guard cells there was no damage to the leaf tissues in oats.

DISCUSSION OF EXPERIMENTS WITH *PUCCINIA GRAMINIS SECALIS*

As was pointed out earlier, macroscopic observations of the experiments with *P. graminis Secalis* indicate that only rye and couch-grass, amongst the plants inoculated, were susceptible to this rust. Two plants of barley, out of a total of sixty-five inoculated, produced pustules, and these were minute and late in developing. Similarly, in Wilhelmina wheat, a weak infection resulted on one plant, out of a total of seventy-three inoculated. Norka wheat and oats were consistently immune.

Microscopic study of fixed leaf areas from Exp. 4 showed that the fungus entered all these plants.

Rye and couch-grass were the only true hosts for the rust. From the beginning the fungus developed more rapidly in rye, and pustules were formed three days earlier than in couch-grass.

In barley infecting hyphae occasionally produced haustoria in the epidermal cells adjacent to the stomata of entry, but no further progress was made. In wheat no further development beyond the formation of infecting hyphae was made, while in oats no infecting hyphae developed from the vesicles.

In all the plants inoculated it was found that, with very few exceptions, the guard cells of the stomata bearing appressoria were killed, whether or not entry was made. Sometimes, in entries in rye and couch-grass, it seemed that only part of the guard cell was injured, and it is perhaps significant that, in all such cases, the discoloured and shrunken end of the guard cell was found always to be the end

which was in contact with the epidermal cell in which the first haustorium was produced.

Finally, mention should be made of the interesting peculiarity that in *P. graminis Secalis* the first haustorium is always formed in an epidermal cell adjacent to the stoma of entry.

SUMMARY

1. Inoculation experiments have been carried out with uredospores of *Puccinia triticina* Erikss., *P. glumarum Tritici* Erikss., *P. anomala* Rostrup, *P. coronata* Corda, *P. graminis Secalis* Erikss., both on their normal hosts and on cereals on which they do not normally occur ("inappropriate hosts").

2. The development of these fungi in the "inappropriate hosts" has been compared with their development in their normal hosts.

3. In general, the relation of the host to the fungus which does not develop on it in nature is one of antagonism, for the mesophyll cells near the stomata of entry are usually killed. On the other hand, the initiation of invasion by these fungi on the "wrong hosts" proceeds normally at first. Exceptionally, the fungus on the "wrong host" kills the guard cells of the stomata of entry, but, failing to develop further than the formation of substomatal vesicles, leads to no further antagonistic reaction on the part of the host.

4. *P. triticina* is not very sharply specialised to wheat, for it sometimes produces normal pustules of uredospores on rye. The different types of reaction between this rust and rye are described. Occasionally minute abortive pustules of this rust were produced on barley, but the relation is usually antagonistic. In oats progress by this rust was negligible, and only once was a haustorium seen.

5. *P. glumarum Tritici* produced intercellular mycelia in rye and barley, but no pustules were formed. Although the fungus entered oats no mycelium developed.

6. *P. anomala* initiated invasion of wheat, rye and oats, killing the guard cells of the stomata of entry but failing to form mycelia in the tissues.

7. *P. coronata* Corda (uredospores from oats) entered wheat, barley, rye, *Lolium perenne* and *L. italicum*, but usually failed to develop beyond the formation of infecting hyphae. The contiguous mesophyll cells were sometimes killed.

8. The initiation of infection by aecidiospores of *Puccinia coronata* Corda from *Rhamnus catharticus* is described on oats, wheat, rye, barley and *Lolium* spp. Progress of the fungus in these hosts was negligible (except in rye), and no uredospores were formed. It is concluded that this biologic form has a host range outside the hosts experimented with.

9. *Puccinia graminis Secalis* from rye and *Agropyron repens* entered wheat, barley and oats, and occasionally produced small pustules of uredospores on barley and wheat. No infecting hyphae were produced from the substomatal vesicles in oats. In the development of *Puccinia graminis Secalis* the first haustorium is always formed in an epidermal cell adjacent to the stoma of entry.

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AN INVESTIGATION OF THE TEMPERATURES LETHAL TO SOME WOOD-DECAYING FUNGI

By H. B. S. MONTGOMERY, B.A.

INTRODUCTION

TIMBER which is apparently sound and serviceable may contain traces of infection which become obvious only when the timber is incorporated in structures and decay has advanced considerably. It is desirable to heat timber suspected of being thus infected in order to kill any fungi present. It sometimes happens that valuable ornamental carved timber becomes infected with a wood-decaying fungus, and the question arises whether it is possible to kill the fungus without damaging the wood. There is thus a need for accurate data concerning the time required at certain temperatures to kill various wood-decaying fungi under known conditions (age, moisture content, etc.).

The literature on the subject is very limited. Snell (3) exposed wood in various stages of decay to heat in sealed Mason jars. He used both dry and moist wood, and showed that a fungus in dry wood resists heat treatment much better than a fungus in moist wood. He worked with rather long time periods, combined with fairly low temperatures. Hubert (1) subjected blocks of various sizes of naturally infected timber to heat for different time periods, chiefly in a Tiemann dry kiln, to determine whether commercial kiln processes were efficient in killing wood-decaying and sap-staining fungi in timber. His time intervals were wide and his results show no great differences in resistance among the various wood-decaying fungi tested. Liese (5) experimented with agar cultures of the fungus and short periods of time at fairly high temperatures.

The following experiments were undertaken to find out what relation, if any, exists between results obtained with agar cultures and those with infected wood blocks, and also to obtain some preliminary figures for the lowest temperatures which would be lethal to various wood-decaying fungi in a reasonably short time.

Cultures of a number of common wood-decaying fungi were obtained from the Forest Products Research Laboratory, Princes Risborough, and subcultured on 2 per cent. malt agar. The fungi used were *Merulius lacrymans* (Wulf.) Fr., *Poria vaporaria* (Pers.) Fr., *Pholiota adiposa* Fr., *Lentinus lepideus* Fr., *Lenzites abietina* Bull., *Lenzites saepiaria* (Wulf.) Fr., *L. striata* Swartz, *L. trabea* Pers., *Polystictus versicolor* (Linn.)

Fr., *Polyporus hispidus* (Bull.) Fr., *Schizophyllum commune* Fr., and *Fomes fraxineus* (Bull.) Fr.

<div align="center">EXPERIMENTAL METHODS</div>

For the purpose of these tests, the fungi were cultured in small blocks 3 × 1 × 1 in. of ash or Scots' pine wood as follows:

ASH	SCOTS' PINE
Lenzites striata	*Merulius lacrymans*
Lenzites trabea	*Poria vaporaria*
Polystictus versicolor	*Pholiota adiposa*
Polyporus hispidus	*Lenzites abietina*
Schizophyllum commune	*Lenzites saepiaria*
Fomes fraxineus	*Lentinus lepideus*

After sterilisation by autoclaving, these blocks were inoculated by placing eight to ten of them on an active malt agar culture of each fungus in a suitable glass vessel. These blocks were allowed to decay for nine months before use, so that the fungus had thoroughly permeated the blocks.

The fungi were also cultured in $\frac{3}{4}$ in. test-tubes containing 10 c.c. (approx.) of 2 per cent. malt agar as slants, and the heat treatments were carried out on these cultures when they were one month old. The treatment was applied by immersing a number of these test-tube cultures in a large bath of water maintained at the desired temperature in a thermostatically controlled oven. At each time interval, one tube culture was removed and allowed to cool. Ten pieces of the culture were then removed from the centre of the slant and transplanted on to a plate of 2 per cent. malt agar. The plates were incubated at a temperature suitable to the fungus (generally 20° C.) for at least one month, and a note was made of any growth which occurred. Where no growth occurred from any of the inocula in a plate, it was concluded that the heat treatment had killed the fungus. The results of these tests are presented in Table I.

It is most important that the inocula should be taken from a standard position in the slant. Inocula derived from the upper end of the slant proved more resistant to heat than inocula from the centre. This resistance seems to be due, in part, to the less moist conditions prevailing at the upper end.

Using these preliminary data as a guide, tests were made with the infected wood material. The 3 × 1 × 1 in. blocks were cut into 1 in. cubes, and all the cubes of wood infected with any one fungus were stored in a glass dish and kept moist. By this means it was hoped to equalise the moisture contents of the blocks for each fungus. The blocks were kept in this manner for periods of over three weeks and up to two months. This proved very satisfactory from the point of view of moisture content, but it permitted moulds to grow on the surface of the blocks. These were troublesome only on wood infected

Table I. *Results with fungi in agar*

	40° C.				55° C.				60° C.		
	15 min.	30 min.	45 min.	60 min.	15 min.	30 min.	60 min.	120 min.	15 min.	30 min.	60 min.
Merulius lacrymans	.	.	.	.	.	.	.	.	.	.	—
	.	.	.	.	.	.	.	.	—	—	.
	—	—	.	.	—	.	.	—	.	.	.
Poria vaporaria	.	—	.	—	.	.	.	.	.	.	—
	.	.	.	.	.	.	.	.	—	—	—
	.	.	.	.	.	.	.	.	.	.	—
Lenzites abietina	.	.	.	.	—	—	.	—	.	.	.
	.	.	.	:	.	.	.	.	.	.	—
	.	.	.	.	.	.	.	.	.	.	—
Pholiota adiposa	.	.	.	:	—	—	—	—	.	—	—
	.	.	.	.	.	.	.	.	.	—	—
Polyporus hispidus	.	.	.	.	—	—	.	—	.	—	—
	.	.	.	.	.	.	.	.	.	—	.
	+	+	+	+	.	.	.	.	.	.	.
Polystictus versicolor	.	.	.	.	—	—	—	—	.	—	—
	.	.	.	.	.	.	.	.	.	—	—
	.	.	.	.	+	+	—	—	—	—	—
	+	+	+	+	.	.	.	.	.	.	.

	60° C.													
	30 min.	45 min.	60 min.	75 min.	90 min.	120 min.	150 min.	180 min.	240 min.	300 min.	360 min.	420 min.	480 min.	540 min.
Lenzites trabea	.	.	+	.	.	—	—	.	—	.	.	.	.	.
	.	.	+	.	+	+	—	.	.	.	.	.	.	.
	+	.	+	+	.	—	—	—	—	.	.	.	.	.
L. saepiaria	.	.	+	.	.	—	—	—	.	.	.	.	.	.
	+	+	+	+	.	.	.	.	.	.	.	.	.	.
	+	+	+	—	.	.	.	.	.	.	.	.	.	.
	.	—	—	.	—	.	.	.	.	.	.	.	.	.
Lentinus lepideus	.	+	+	+	+	.	.	.	.	.	.	.	.	.
	+	+	+	+	.	+	.	+	+	.	.	.	.	.
	.	.	.	.	.	+	.	.	+	.	+	.	+	+
Schizophyllum commune	.	.	+	.	.	+	.	+	+	+	+	+	+	+
	.	.	.	.	.	.	.	.	.	+	+	+	+	.
	.	.	.	.	.	.	.	.	.	+	+	+	.	.
Lenzites striata	.	.	—	.	.	—	.	.	.	.	—	—	—	—
	+	+	+	+	.	.	.	.	.	.	.	.	.	.
	+	.	+	.	+	+	—	.	.	.	.	.	.	.
	.	.	.	.	—	—	.	—	.	.	.	.	.	.
	.	.	.	.	+	+	+	+	.	.	.	.	.	.
Fomes fraxineus	.	.	+	+	.	+	+	.	.	.	.	.	.	.
	.	.	.	.	.	—	.	.	.	—	—	—	—	.
	.	.	.	.	.	.	.	.	.	—	—	—	—	.
	.	.	.	.	.	.	.	.	—	—	—	—	—	.

Note. Each — or + indicates the absence or presence of fungal growth from a single test-tube culture.

with certain fungi, ash wood infected with *Polyporus hispidus* being particularly prone to mould attack.

Various methods of heating the wood blocks in a water bath, avoiding loss or gain of moisture, were considered. It was thought undesirable to put them in a glass vessel—such as a test-tube or a Mason jar—for treatment, since heating to the desired temperature would be a slow process, and further, exchange of moisture might occur between the block and the relatively large volume of air (either saturated or dry) in the glass vessel. Experiments were then made with methods of coating the block with some impervious paint or varnish, but, apart from the risk of vapours from the paint having a toxic effect, it was found almost impossible to render the block watertight. Finally, thin sheet rubber was used. This was first cemented with rubber solution into tubes about 4 in. long and wide enough to accommodate conveniently a 1 in. cube. After putting a block into a tube, the ends were tightly tied with twine, thus forming a watertight bag. By this method, a very small volume of free air was included and the block was in close contact with the source of heat. The rubber bags, each containing one block, were submerged, by means of a wire basket, in a large bath of water maintained at the desired temperature.* One block was removed at the end of each time period, and, after cooling, it was flamed on the surface and split in half. From this freshly exposed surface of each half, five small splints were removed and placed on prune agar in a Petri dish. Thus, in all, ten splints of wood were removed from the centre of each block. The inoculated dishes were stored at 20° C. (approx.), and where no growth occurred after one month, the fungus was considered killed. The figures are presented in Table II. To keep a check on the moisture content of the blocks during treatment, a control block was enclosed in a rubber bag, and submerged in the bath for the course of the treatment, and its moisture content was determined after cooling as a percentage of oven-dry weight. This moisture content was assumed to be similar to that of the other blocks similarly decayed and heat treated.

In view of the uniformity of the results, it would seem that the variation in moisture content of these blocks was not large enough to affect the resistance of the fungus to heat. It is also of interest that these moisture contents all permitted the fungi to grow freely.

* The temperature was kept constant by manipulation of a fine adjustment on the gas supply, a mechanical thermostat not being available. The temperature varied ± 1° C.

Table II. *Results with fungi in wood*

	40° C.						55° C.						Average % moisture
	15 min.	30 min.	60 min.	90 min.	120 min.	150 min.	15 min.	30 min.	45 min.	60 min.	90 min.	120 min.	
Merulius lacrymans	−	−	−	−	−	·	·	·	·	·	·	·	103
	−	−	−	−	·	·	·	·	·	·	·	·	
Poria vaporaria	+	+	+	+	+	·	·	·	·	·	·	·	59
	·	·	·	·	·	·	−	−	−	−	−	−	
	·	·	·	·	·	·	−	−	−	−	−	−	
Lenzites abietina	·	·	+	+	+	·	−	−	−	−	−	·	105
	·	·	·	·	·	·	−	−	−	−	−	−	
	·	·	·	·	·	·	−	−	−	−	−	−	
Pholiota adiposa	+	·	+	+	+	−	−	−	−	−	−	·	35
	·	·	·	·	·	·	−	−	−	−	−	−	
	·	·	·	·	·	·	−	−	−	−	−	−	
Polyporus hispidus	·	·	·	·	·	·	−	−	−	−	−	−	46
	·	·	·	·	·	·	−	−	−	−	−	−	
	·	·	·	·	·	·	−	−	−	−	−	·	
Polystictus versicolor	·	·	·	·	·	·	+	+	·	+	−	−	55
	·	·	·	·	·	·	+	+	+	+	−	−	

	60° C.						65° C.					Average % moisture
	15 min.	30 min.	60 min.	90 min.	120 min.	150 min.	15 min.	30 min.	60 min.	90 min.	120 min.	
Lenzites trabea	·	·	·	−	−	−	·	·	·	·	·	46
	·	−	−	−	−	−	·	·	·	·	·	
	·	+	+	−	−	−	·	·	·	·	·	
L. saepiaria	+	+	+	+	−	·	·	·	·	·	·	63
	·	·	+	−	−	−	·	·	·	·	·	
	·	+	+	+	+	−	·	·	·	·	·	
	·	+	+	−	−	−	·	·	·	·	·	
	·	+	−	−	−	−	·	·	·	·	·	
Lentinus lepideus	·	·	·	·	·	·	·	+	−	−	−	45
	·	·	·	·	·	·	·	+	−	−	−	
	·	·	·	·	·	·	·	−	−	−	−	
	·	+	+	+	−	−	+	+	·	·	·	
Schizophyllum commune	·	·	·	·	·	·	·	−	−	·	−	31
	·	·	·	·	·	·	+	−	−	·	−	
	·	·	·	·	·	·	·	−	−	−	·	
Lenzites striata	·	·	+	+	+	·	·	−	−	−	−	61
	·	·	·	·	·	·	·	−	−	−	−	
	·	·	·	·	·	·	·	−	−	−	·	
Fomes fraxineus	·	·	+	−	−	·	·	−	−	−	−	54
	·	·	·	·	·	·	·	−	−	−	−	
	·	·	−	−	−	·	·	−	−	·	·	

Note. Each − or + indicates the absence or presence of fungal growth from a single test-block.

Results

From a study of the tabulated results it will be seen that great variation in heat resistance is shown by wood-destroying fungi.

The most resistant of the fungi tested, *Lentinus lepideus*, was killed in moist wood (1 in. cubes) by treatment for sixty minutes at 65° C.

Comparison of Tables I and II shows that close correlation exists between the times taken to kill a fungus by heat in agar culture and in wood blocks.

Summary

An account is given of experiments made to determine the time, at certain temperatures, required to kill a number of wood-decaying fungi both in agar culture and also in moist wood blocks. The results are given in tabular form.

A new method is outlined for the experimental heat treatment of wood on a small scale, by the use of rubber bags.

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THE PARASITISM OF *BOTRYTIS CINEREA* PERS. ON *AUCUBA JAPONICA* THUNB.

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(With Plates VI and VII)

INTRODUCTION

WHILE a number of cuttings of *Aucuba japonica* Thunb. were being kept in sterile boiling tubes as experimental material for the investigation of a blight of that shrub it was observed that one of the cuttings became affected by a rapid brown rot which, by the end of several days, had killed it completely. As further investigation showed that the disease was due to the parasitic invasion of *Botrytis cinerea* Pers., it was considered desirable that the symptoms and effects of the disease as well as the life history of the causal agent should be described in detail sufficient to render certain a pathogenicity hitherto unrecorded for this host (1, 2).

ISOLATION OF FUNGUS AND ESTABLISHMENT OF PARASITISM

The specimen on which the attack was first observed (Pl. VI, fig. 1) bore an inflorescence in the cleft between the branches of the forked stem. The fact that other cuttings without flowers after being similarly tubed for several months not only showed no signs of disintegration but had, on the contrary, produced an adventitious root system near the cut end of the stem, which rested on cotton-wool in sterile water at the base of the tube, suggested that there might be a more than fortuitous connection between the presence of an inflorescence and the occurrence of decay. It was, indeed, only at the uncuticularised surface of the nectaries that infection of undamaged twigs could be effected. This is clearly shown (Pl. VI, fig. 1) by the inability of the superficial mycelium to penetrate the intact surface of the, as yet, unattacked portion of the stem below the peduncle. The necrosis had, as indicated (Pl. VI, fig. 1), spread upwards into the younger, more succulent tissues of the limbs of the fork but when a portion of this necrotic tissue was excised after surface sterilisation and transferred on the point of a sterile scalpel to the floral nectaries of another twig the disease first spread downwards into the harder tissues of the older part of the stem (Pl. VI, fig. 2). Pieces of diseased tissues removed with the usual aseptic precautions, and planted on the sterile agar surfaces of poured plates yielded, after twenty-four to forty-eight

hours' incubation at 20° C., abundant growth of pure mycelium of characteristic *Botrytis* form from which subcultures of unquestionable purity were then obtained by hyphal tip transfers. With the fungus from diseased twigs, thus isolated in pure culture, inoculations were carried out on healthy twigs freshly cut and enclosed in sterile boiling tubes. When such a twig was abraded or incised with a sterile instrument following the surface sterilisation of selected areas, and the fungus introduced by implantation on drops of solidified sterile agar placed on these sites, the presence of brown necrotic symptoms was apparent by the end of the first day. Where the mid-rib region of the lamina, the stem apex and the nodes were inoculated (Pl. VI, fig. 3) the signs of fungal invasion, as indicated externally by the appearance of a brown rot, spread out in all directions through vascular and ground tissue alike and had reached the limits shown by the third day (Pl. VI, fig. 3). On re-isolation of the fungus from twigs diseased as a result of artificial inoculation it proved to be morphologically and culturally identical with that originally isolated and subsequently used as inoculum. Control twigs similarly treated, but for the omission of the suspected pathogen, remained perfectly healthy over the protracted period of observation.

It should be mentioned at this point that, in spite of the proved virulence of the parasitism of the fungus for healthy and even vigorously growing tissues of *Aucuba*, no evidence of disease attributable to this fungus was found in nature nor was it ever isolated from the lesions of *Aucuba* plants affected by blight or other naturally occurring form of disease. From this it seems that not only is the presence of an exposed or injured surface essential to infection by the fungus but also that the determining factor in its progressive invasion is the concomitance of the moist, enclosed conditions under which the inoculation experiments were conducted.

PATHOLOGICAL HISTOLOGY

The nature of the invasion was also examined histologically by fixing, in Flemming's strong fluid, portions taken from the externally visible region of demarcation between the brown infected and green healthy tissues and cutting longitudinal sections 4μ thick. Examination of suitably stained sections from the apical part of a stem, including the basal portions of the petioles of the apical leaves, which had been inoculated some distance below the apex, showed that the rot was due to an indiscriminate or parenchymo-vascular attack on the tissues with intracellular penetration of the hyphae. Since the material referred to was in active growth when fungal invasion took place there was little distinction between the rate or mode of progress of the fungus in the vascular tracts and cortex and

pith respectively, except that the hyphae tended to run more longi-
tudinally in the primordial vascular strands, where the septate
character of the mycelium could readily be recognised, compared
with their more tortuous course in the ground parenchyma. Stained
with Flemming's triple stain the tips of the leading hyphae, retaining
the safranin more strongly than the older vacuolate segments of the
mycelium, showed clearly the intracellular invasive powers of the
parasite (Pl. VII, fig. 1). A better stain for showing the general
distribution of the pathogen in the host tissues is a solution of 1 per
cent. cotton blue in lactophenol. Sections stained for three days in
this medium and differentiated for about half that period in the pure
solvent (lactophenol) show bright blue fungal cytoplasm and un-
stained hyphal walls while the walls and cytoplasm of the host cells
are almost colourless and the nuclei pale greenish blue (Pl. VII,
fig. 2). The central hypha shown invests the less intensely stained
circular nucleus at the centre of the cortical host cell; the black spots
in the body of the fungus are oil globules stained by the osmic acid
of the fixative.

IDENTIFICATION OF THE PATHOGEN

In establishing the identity of the causal agent as *Botrytis cinerea*
Pers. the life history of the organism was briefly worked out in pure
culture. Infected tissues from the interior of a diseased plant were
sown at opposite sides of a poured plate on the sterile surface of agar
prepared with a decoction of *Aucuba* twigs. Three days later typical
hyaline greyish white *Botrytis* mycelium had grown out from these
opposing inocula and covered almost the entire available surface
of the agar with spreading hyphae which showed characteristic
branchings (Pl. VII, fig. 3). After a further day or so aerial hyphae
arose, principally around the margins of the Petri dish and along
the junction of opposing growths, and when examined microscopi-
cally were seen to consist mainly of stouter brownish conidiophores
which bore at their distal ends clusters of typical *Botrytis* conidia
(Pl. VII, fig. 4). On a synthetic medium of sucrose 2 per cent.,
KNO_3 0.2 per cent., $MgSO_4$ $7H_2O$ and KH_2PO_4 0.05 per cent.
each and washed agar 3 per cent., the mycelium after rapidly covering
the available agar surface becomes denser and, probably because of
that, appears much whiter. A short time later (five to six days in all)
it is observed that at a number of points on the agar surface the
hyphae have aggregated to form round, discrete, black sclerotia on
the outside of which beadlets of exuded water can be seen (Pl. VII,
fig. 5). When transferred to a fresh agar surface these sclerotia imme-
diately germinate to produce an extensive mycelial system which,
when it has exhausted the immediately available nutriment or pro-
duced a staling depressor, aggregates to form a fresh crop of resistant

sclerotia. Sclerotia are also formed at the surface of *Aucuba* stems killed by the fungus and when mature they become rounded off and fall away. In the dead leaves sclerotia of a different type are found. The fungus here forms irregular patches of pseudo-hypertrophy in the mesophyll the protuberance being towards the abaxial side and its limits often being defined by the course of the larger veins. An even more rapid production of sclerotia could be obtained by inoculating young succulent autoclaved twigs of *Aucuba* with the sporulating mycelium of *Botrytis*, when large numbers of sclerotia as well as abundant conidial fructifications were soon evident at the surface of the twigs.*

SUMMARY

Healthy twigs of *Aucuba japonica* Thunb. are actively parasitised by *Botrytis cinerea* Pers. under conditions of enclosed humidity and provided some susceptible ingress is afforded the pathogen in the form of an unprotected nectary surface or mechanical interruption of the cuticle.

The signs of the disease and its course are described and the nature of the invasion examined histologically.

In identification, the various phases in the life history of the causal organism have been briefly outlined.

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EXPLANATION OF PLATES VI AND VII
PLATE VI

Fig. 1. Experimental cutting of *Aucuba* from boiling tube. *Botrytis* infection has taken place through the exposed stigmata and nectaries and the rot has spread from the peduncle into both limbs of the fork as far as the levels indicated. The growing points of the branches have been killed and the necrosis is spreading to the petioles of the apical leaves. × 2.

Fig. 2. Infection has occurred as described for fig. 1, but the disease has advanced into the older, more woody part of the stem below the peduncle to the point shown: the younger, more succulent branches, above the junction of inflorescence and main axis, have not yet been affected. × ⅔.

Fig. 3. Result, after three days, of artificial inoculations of an *Aucuba* twig with sporulating mycelium of *Botrytis* isolated from lesions similar to those depicted in figs. 1 and 2. The artificially induced lesions have spread from the sites of inoculation at (1) the mid-rib of the lower left-hand leaf at the mid-laminal region, (2) the open surface of the petiole of the left-hand apical leaf deprived of its lamina, and (3) the stem just above the lowest node shown. The limits of the general tissue rot are as defined. × 1.

* The sclerotia being produced towards the moister lower end of the twig and the conidia at the drier surface near the top.
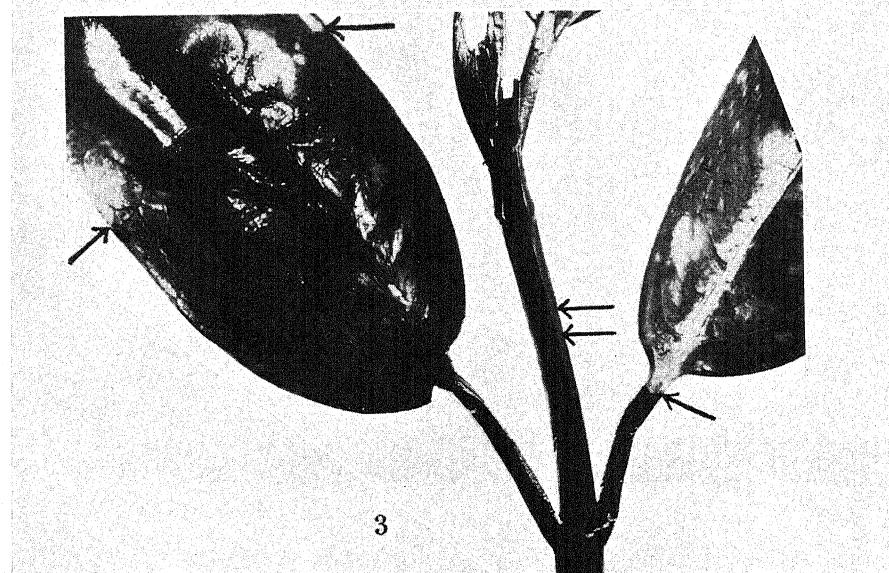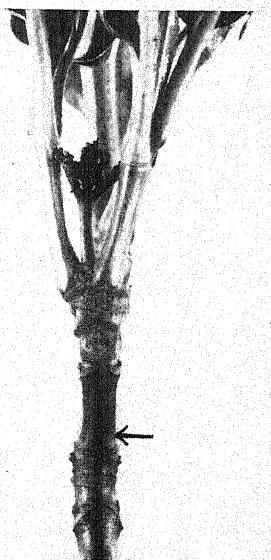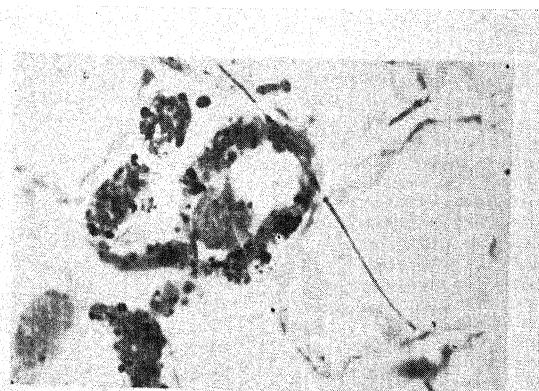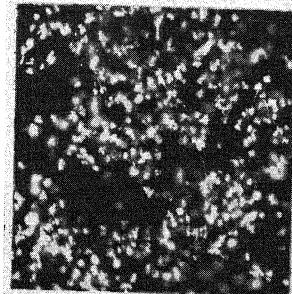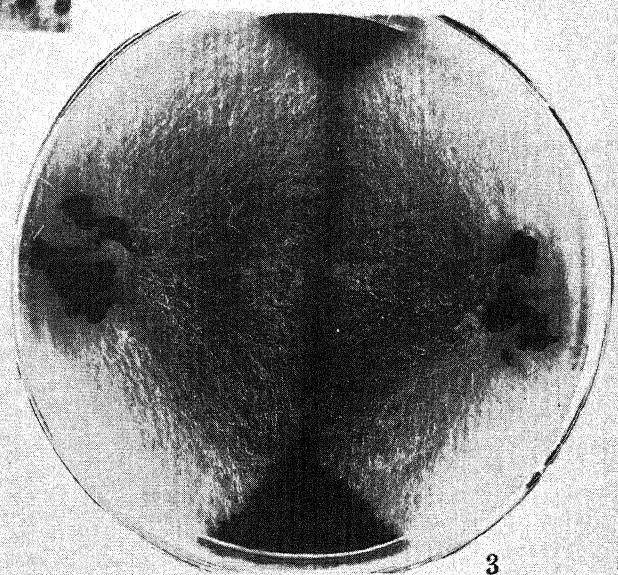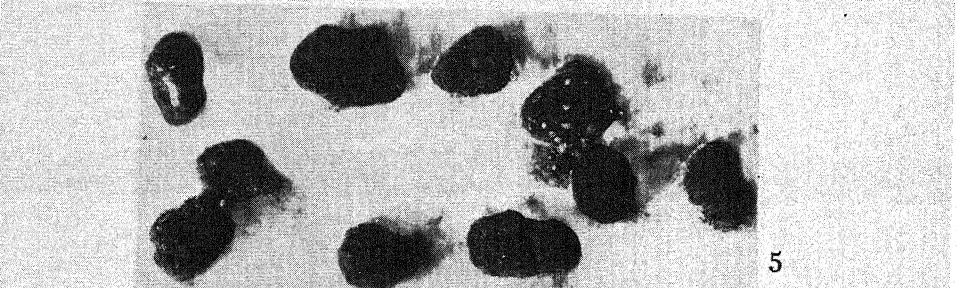
PLATE VII

Fig. 1. Longitudinal section of an infected *Aucuba* stem showing the parasitic *Botrytis* mycelium. The densely granular advance hypha of the invasion is penetrating the host cells of an apical petiole. Stained Flemming's triple stain. ×830.

Fig. 2. Hypha ramifying in the cells of the killed cortical region of an *Aucuba* stem (from a section similar to that described for fig. 1). The more lightly stained circular bodies are the host nuclei. Sections from material fixed in Flemming's strong fluid and stained with cotton blue in lactophenol. ×780.

Fig. 3. Re-isolation of *Botrytis* in pure culture on agar. Inocula derived from artificially infected *Aucuba* stem lesion (three days old culture). ×¾.

Fig. 4. Conidial heads of the aerial mycelium. Note typical clusters of *Botrytis* conidia. ×11.

Fig. 5. Group of *Botrytis* sclerotia standing out from dense white parent mycelium showing surface morphology and droplets of exuded moisture (from six days old subculture on nutrient agar). ×4.

Figs. 3, 4 and 5 photographed by reflected light.

NOTES ON A TECHNIQUE FOR THE LABORATORY EVALUATION OF PROTECTIVE FUNGICIDES

By R. W. MARSH

(With 1 Text-figure)

THE usefulness of laboratory tests of protective fungicides has recently been pointed out by Montgomery & Moore (1) who have summarised many of the difficulties involved. Montgomery & Moore describe a method of testing based on the distribution of a drop of spray fluid of known volume over a given area on a glass slide. The writer has attempted to carry out parallel tests on slides and on leaves, and for this purpose it has been found necessary to apply the spray by means of an atomiser. The defect of glass slides is that spray fluids may spread too readily on them: this has been remedied by using slides previously covered with cellulose according to the method described by Evans & Martin (2). A brief description follows of the routine adopted in carrying out tests on slides and on leaves, together with a comparison of some of the results obtained.

TESTS ON SLIDES

Glass microscope slides 3×1 in. are "cellulosed" by dipping them in a solution of nitro-cellulose in butyl acetate, allowing them to drain and then dry in the laboratory for two or three days. The dry cellulose film is easily detachable in water, so that, in slides that are to be leached, the film must be sealed around the glass by placing small drops of a gum such as Euparal (3) along the edge of the slide.

A standardised method of spraying the slides was adopted using an atomising apparatus of the type described by Evans & Martin (2). The essential feature of the apparatus is the two jets cut from stainless steel tubing of 0·022 in. diameter. The air pressure employed is two atmospheres and the slide is exposed for ten seconds opposite and at a distance of 2 ft. from the spray jet in the plane at right angles to the axis of the spray cone. This exposure gives an even deposit of minute droplets on the sprayed surface at the rate of 0·05 c.c. of spray fluid per square inch.

After being sprayed, the slides are allowed to dry in the laboratory for two days and then, if a leaching treatment is desired, they are submerged for an hour in a litre of fresh rainwater in a glass dish. After leaching, the slides are then again allowed to dry in the laboratory.

The spores used for a test of the toxicity of the spray deposit are conidia of *Venturia inaequalis*, taken from the youngest visible naturally occurring leaf infections on leaves of Crimson Cox apple. A suspension of these conidia is made in tap water and three drops of the suspension, each of approximately 0·015 c.c., are placed in line at 1 cm. intervals along the middle of the sprayed side of the slide. The concentration of the suspension is such that each. drop contains 200–300 conidia. The inoculated slide is then inverted and enclosed over water in a Petri dish. After twenty-four hours in the laboratory a count of spore germination is made; the slide is then returned to the Petri dish and a second count is made after a further twenty-four hours.

Tests on leaves

Apple leaves of the variety Crimson Cox are employed and in the early part of the season these are obtained by cutting spurs from the tree but from July onwards extension shoots 1 ft. to 1 ft. 6 in. long are taken. A single young leaf about $1\frac{1}{2}$ in. long is selected near the tip of the shoot and this leaf is allowed to remain attached to the stem, the others being removed. For the spray treatment, the procedure is exactly as described for the cellulosed slides, the stem bearing the single leaf being supported so that the leaf stands at right angles to the path of the spray with the upper surface of the leaf facing the jet. After the spray application, the stem carrying the treated leaf is placed with the cut end in water and the spray deposit is allowed to dry in the laboratory for forty-eight hours. If the leaf is to be leached it is then subjected to a sprinkling process simulating natural rainfall. In this process, distilled water is allowed to issue at the rate of twelve litres per hour from a fine rose, and the jets thus produced fall approximately a foot on to the leaf upper surface supported in a horizontal position. This treatment is continued for an hour, after which the leaf is again permitted to dry in the laboratory for a further twenty-four hours, the cut end of the stem meanwhile remaining in water.

Before inoculation, the shoot bearing the treated leaf is shortened to about 2 in. and the cut end of the shoot is placed in water in a specimen tube (3 × 1 in.). Inoculation of the leaf is carried out using the same spore suspension as is employed for the slides, two drops each of 0·015 c.c. being placed on the upper surface, one on either side of the midrib.

The inoculated leaf is immediately covered by a glass bulb ($2\frac{1}{2}$ in. long and 1 in. diameter) having the lower end open. This lower end is then fitted within the top of the collecting tube, water is added to fill the tube and the orifice of the bulb is thus sealed enclosing the

leaf in a moist chamber (see Fig. 1). The whole apparatus is then kept in a humid atmosphere under a bell jar in the laboratory for twenty-four hours.

At the end of this incubation period the small section of the leaf carrying one of the drops is cut out and the leaf then returned to the moist chamber as before. The excised portion is warmed on a slide in a clearing fluid made by mixing equal weights of crystalline chloral hydrate and crystalline phenol, both being first made fluid by heating. In this clearing fluid the leaf fragment becomes translucent in one or two minutes. The preparation is then examined microscopically and a count is made of the total number of spores and of the number germinated. With apple scab conidia the germ tubes are visible without staining.

Fig. 1. Apparatus for spore germination tests on leaves. (For description see text.)

After a further twenty-four hours the second inoculation drop remaining on the leaf is similarly prepared for a germination count.

It is found that preparations treated with the chloral hydrate-phenol mixture can be examined without further treatment for approximately a week after clearing.

RESULTS

Table I sets out the results obtained with four types of treatment—no spray, lime sulphur, cuprous cyanide and cupric ferrocyanide. The lime sulphur was used at 1 per cent. strength (by volume), the copper compounds at a concentration equivalent to 2 gm. Cu per litre. The latter materials were supplied by Imperial Chemical Industries, Ltd., in the form of pastes giving excellent dispersion in water. Tests made showed that the dispersing agent used was without fungicidal action.

To avoid complexity, the results given in Table I are all taken from surfaces that have not been leached, and the table is planned to facilitate comparison between corresponding treatments on slides and on leaves. While there are certain wide variations in the germination figures relating to the same treatment, the results agree in showing that the spray deposit of cuprous cyanide in these tests was completely fungicidal on slides but of indifferent fungicidal power on leaves. Again, with the spray deposits from cupric ferrocyanide and from lime sulphur, the toxicity shown on leaf surfaces was significantly less than that shown on the cellulosed slides.

In the unsprayed series, the germination on leaves was significantly

Table I. *Percentage germinations of apple scab conidia*

1935	On unsprayed surfaces				On surfaces sprayed with lime sulphur				On surfaces sprayed with cuprous cyanide				On surfaces sprayed with cupric ferrocyanide			
	Germination after 24 hr.		Germination after 48 hr.		Germination after 24 hr.		Germination after 48 hr.		Germination after 24 hr.		Germination after 48 hr.		Germination after 24 hr.		Germination after 48 hr.	
	On slides	On leaves	On slides	On leaves	On slides	On leaves	On slides	On leaves	On slides	On leaves	On slides	On leaves	On slides	On leaves	On slides	On leaves
Apr. 26	77 74	73 74	·	·	11	8	0	9	0	29	0	·	·	·	·	·
May 9	82 70	84 93	·	·	·	·	·	·	·	·	·	·	31	73	68	92
May 16	75 71	87	75 70	90	·	·	·	·	0	40	0	33	0	58	0	53
May 23	80 72	83 82	·	91 93	0	29	0	90	0	65	0	25	0	72	0	70
May 31	·	·	80 81	86 87	·	·	47	10	·	·	·	·	·	·	0	53
June 14	48 66	83 70	65 69	56 74	0	·	0	·	0	0	0	0	0	35	0	60
June 22	79 77	85 87	86 89	92 91	0	73 78 78 40	0	84 85 65 46	0	35 51 43 46	0	47 76 46 24	·	·	·	·
Mean	72	82	77	84	3	44	12	56	0	39	0	36	8	60	14	66
Standard deviation	9·0	6·9	8·5	12·1	·	·	·	·	·	·	·	·	·	·	·	·

Comparing columns 1 and 2, difference between means = 10
Standard error of above difference = 3·3
i.e. difference is significant.

Comparing columns 3 and 4, difference between means = 7
Standard error of above difference = 5
i.e. difference is not significant.

better than that on slides in the count taken twenty-four hours after sowing, but no significant difference was shown on the count taken after forty-eight hours. This would suggest a stimulating effect by the leaf sufficient to accelerate germination, but further data are required to decide this point.

Comparing the sprayed leaves with the sprayed slides, it is possible that the less effective performance of the fungicide on the former is related to a stimulatory effect of the leaf on spore germination but in considering this point the possibility of other influences must be borne in mind. If a reducing substance is produced by the leaf surface then the fungicidal effect of a sulphur-containing spray deposit might, on the hypothesis of Barker (4) be greater on a leaf than on a slide. Conversely, if the fungicidal value of a cuprous salt is dependent on its conversion to the cupric form, a reducing effect on the leaf surface should be prejudicial to the effectiveness of cuprous cyanide. It may be suggested that these biochemical influences of the leaf are outweighed by the factor of the distribution of the spray deposit. The cellulosed slide provides a perfectly plane surface while the leaf presents an epidermis diversified by irregularities, obstructed by hairs, and capable of growth after spray treatment. Therefore while the slide and the leaf may receive precisely the same spray treatment, the spray deposit encountered by the fungus spores in the germination test may be less evenly distributed on the leaf surface than on the slide. Further experiments may show whether this supposition is justified but in the meantime it appears correct to say that in the tests reported above, the living leaf has proved less flattering to the fungicide than has the slide.

SUMMARY

1. A technique is suggested for the laboratory evaluation of protective fungicides using (*a*) cellulosed slides, (*b*) living leaves.

2. Using the same spray treatment on slides and on leaves the spray deposits from cuprous cyanide, from cupric ferrocyanide and from lime sulphur displayed less fungicidal effect on leaves than on slides.

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A NOTE ON THE GROWTH OF THE APPLE SCAB FUNGUS (*VENTURIA INAEQUALIS* ADERH.) ON BRAMLEY'S SEEDLING APPLES DURING THE WINTER 1934–1935

By W. F. CHEAL, D.I.C.

THE breakdown in the resistance of Bramley's Seedling to attacks of the apple scab fungus has become a matter of great economic importance. In certain districts, spraying trials in 1934 showed that two pre-blossom fungicide applications in addition to the usual treatment after the flowering period were necessary in order to obtain a successful scab control: the spray programme for Bramley's equalled the drastic measures required for the most susceptible varieties, *e.g.* Worcester Pearmain.

Storage problems in 1934 were made very difficult by the large crop, and many tons of Bramley's Seedling apples were kept under outdoor conditions—in clamps, or in orchard boxes stacked and roofed with straw.

It was noticeable late in October of that year that scab colonies on Bramley's apples kept out-of-doors were unusually vigorous; fruit from spraying trials, which had been graded for scab in the previous month had to be placed in a higher category for scab infection. Even in the following month fungal growth appeared to be active, and in December it was decided to make some detailed observations.

Four Bramley's Seedling apples each about 8 oz. in weight, infected with scab, were selected on December 10, 1934, and the positions and dimensions of fifteen scab colonies were recorded. The maximum and minimum diameters of each colony were measured.

The apples were kept in a chip basket placed in a small grass enclosure at Wisbech, and the fungal colonies were measured on December 28, 1934, and again on February 13, 1935.

The figures obtained are shown in Table I.

With three exceptions, growth took place on all the colonies under observation.

The winter 1934–5 was an extremely mild one, and the high temperature for December was outstanding.

The weather conditions permitted scab to develop even on apples stored in the open. The present note therefore confirms the observations of Dr H. Wormald* who found that scab spots may increase in

* *J. Min. Agric.* September, 1934.

size on Bismarck apples in storage during winter, and this fact emphasises the importance of "pin spot" scab at picking time.

Table I

Apple	Fungus colony	Dec. 10, 1934 mm.	Dec. 28, 1934 mm.	Feb. 13, 1935 mm.
A	i	13 × 5	14 × 5·5	Fruit bird pecked and rotten
	ii	6 × 7	7 × 8	,,
B	i	7 × 6	7 × 6	7 × 6
	ii	5 × 4·5	6·5 × 5	7 × 6
	iii	5 × 5	5 × 5	5 × 5
	iv	7 × 6	8 × 6	8 × 7
	v	3 × 4	4 × 5	5 × 5
	vi	4 × 4	4·5 × 4	5 × 5
C	i	7 × 9	8 × 10·5	11 × 9
	ii	5 × 4	5·5 × 5	6 × 5·5
	iii	3 × 3·5	4·5 × 4	5 × 4·5
	iv	5 × 4	6 × 4·5	6 × 5·5
	v	7 × 4	7·75 × 4	9 × 5
D	i	7 × 7	7 × 7	7 × 7
	ii	3 × 3	4 × 4	5 × 5·5

Average diameter of 13 colonies on apples B, C and D 5·076 mm. (Dec. 10, 1934), 6·23 mm. (Feb. 13, 1935).

REVIEWS

Le Genre Galera (Fr.) Quélet. By ROBERT KÜHNER. (Paul Lechevalier. Paris. Frs. 75.)

The determination of the smaller agarics is beset with difficulties, and monographs are badly needed. The well-known French mycologist Robert Kühner, has given us the results of many years' continuous work on the genus *Galera*. He describes 44 species with many varieties and forms.

The species are grouped into two genera and two sub-genera, including many of the smaller Pholiotas and Naucorias, the microscopic characters of which, in the author's view, place them among the Galeras. We regret the disappearance of *Galera* as a genus.

The descriptions are full and the microscopic characters are given in great detail. There are no coloured plates, but numerous figures of spores, basidia and cystidia. A key to the species is provided.

The author is to be heartily congratulated on his achievement.

A. A. P.

Flora Agaricina Danica. By JAKOB E. LANGE.

The name of Jakob E. Lange is familiar to all students of the agarics. He has produced a series of brochures that have been published at fairly regular invervals since 1914, dealing chiefly with the microscopic characters of various genera. He has always referred us to his paintings, but as they are in Denmark, few mycologists have had the advantage of consulting them. At last he has made arrangements to have these paintings reproduced under the title *Flora Agaricina Danica* and the first half of Part I has been published in Copenhagen by the Society for the Advancement of Mycology in Denmark and the Danish Botanical Society. It consists of 16 coloured plates and 40 pages of brief descriptions. Several species are on each plate, and they are splendid examples of the mycologist's art; the colourist and the systematist combining to give a recognisable picture of the species.

The figures of uncommon agarics will be of great assistance to agaricologists, and we hope that the work will receive the recognition it so fully deserves.

A. A. P.

PROCEEDINGS

Meeting held at University College, London, January 19, 1935.

President: MALCOLM WILSON, D.Sc., F.R.S.E., F.L.S.

L. E. HAWKER. Factors influencing sporulation of *Melanospora* and some other fungi.

A strain of *Melanospora destruens* was found to fruit more freely in the presence of certain other fungi than it did in pure culture. Reduction in the glucose content of the medium or transference from the normal medium to a more dilute one increased to some extent the number of perithecia formed. Media prepared from nutrient liquids in which certain other fungi had been growing were more favourable to perithecial formation than was fresh ("unstaled") medium. Evidence was obtained that the stimulatory effect of certain fungi was due to a combination of three factors, i.e. reduction in food content of the medium, production of "staling" substances by the fungus and production of a definite stimulatory substance or substances. An extract of lentils known to contain accessory substances essential for the growth of *Nematospora Gossypii* stimulated the sporulation of *Melanospora* to a striking extent. The effects of lentil extract were compared with those of certain staled media, under a variety of conditions, and it was suggested that the stimulatory substances concerned were the same or at least very similar.

R. HULL. Investigation of the control of spoilage of processed fruit by *Byssochlamys fulva*.

The presence or absence of *Byssochlamys fulva*, a spoilage agent of processed fruit, in any given material was determined by incubating at 30° C. samples of leaves, fruit and straw, collected in plugged sterile tubes filled with hot potato-sucrose agar, acidified to $pH\,3$ and heated at 80° for 30 minutes, the ascospores of this fungus being resistant to this temperature.

Positive infections were obtained from diseased and healthy samples collected during several months and from several localities, including Colchester, Kent and Gloucestershire. Elimination of the fungus from the field is therefore evidently impracticable.

In studying possible control practices in the factory disinfectants were found to be ineffectual, a temperature of 92° C. was necessary to kill the ascospores in $1\frac{1}{2}$ minutes, increase in sucrose up to 20 per cent. made the spores more resistant but at higher concentration the germination rate declined. It is hoped to make further investigations to discover the best way of destroying the fungus within the limits set by the canning process.

J. RAMSBOTTOM. A British species of *Kordyana*.

An account was given of the genus *Kordyana* and a new species was described which had been found on *Scirpus lacustris* in England.

Meeting held at University College, London, March 16, 1935.
President: MALCOLM WILSON, D.Sc., F.R.S.E., F.L.S.

A. BURGES. Mycorrhizal Investigation in Australia.

The widespread nature of fungal infection of a mycorrhizal type was emphasised and a brief account given of the extent to which mycorrhiza had been found in Australian plants. Mention was made of McLennan's work on *Lolium* and of McLuckie's on the New South Wales Orchids.

Then followed a more detailed account of the mycorrhiza of *Eriostemon Crowei* as described by McLuckie and Burges and of *Lobelia* as described by Fraser.

In *Eriostemon* two types of fungal invasion were recorded, a *Rhizoctonia* infection of the superficial cells and an extensive infection by an arbuscule- and vesicle-forming fungus. The morphological changes seen in the arbuscules and vesicles were described.

In *Lobelia* an unusual mycorrhizal infection is found. Penetration is from rhizomorphic strands and the mycelium develops extensively in the intercellular spaces which are greatly enlarged. The hyphae become filled with oil. Later the hyphae are crushed by the cells and the oil disappears; at the same time oil appears in the cells of *Lobelia*.

D. M. CAYLEY. Spores and spore germination in wild and cultivated mushrooms.

W. P. FINDLAY. Some observations on the fungi occurring in coal mines.

Fungal decay of pitwood is sometimes very rapid in shallow damp mines: this rot occurs mainly in the props used in the permanent roads and in the return airways. The majority of the pit props used in this country are of coniferous timber. The sporophores produced in mines are often abnormal; in many species of Agaricaceae the pileus is greatly reduced and the stipe is elongated and branched, while in the Polyporaceae the sterile tissue is often reduced and the fructification may consist of a pore surface only.

The principal species found attacking softwood props are *Poria Vaillantii* and other similar species of *Poria, Merulius lacrymans, Paxillus panuoides, Lentinus lepideus, Coniophora cerebella, Fomes annosus* and *Armillaria mellea*. On hardwood props *Polystictus versicolor* and *Stereum hirsutum* are common.

Preservation of the props by impregnation with a 2 % solution of zinc chloride or of sodium fluoride applied by the "hot and cold" open tank process, greatly increases the life of the props—pitwood treated in this way will last five to ten times as long as the untreated and, therefore, such treatment is definitely an economic proposition.

E. M. WAKEFIELD. An edible species of *Volvaria*.

Miss Wakefield exhibited a specimen of *Volvaria volvacea*, an uncommon and edible species of a genus until recently regarded as entirely poisonous.

J. RAMSBOTTOM and E. M. WAKEFIELD. Mycological Nomenclature.

Mr J. Ramsbottom read a communication from Mr T. Petch which dealt with the difficulties in applying the International Rules of Botanical Nomenclature in so far as they referred to fungi. It was suggested that much of the trouble would be obviated if Saccardo's *Sylloge Fungorum* were taken as the starting point.

Mr Ramsbottom then gave a summary of the history of Botanical Nomenclature and indicated the main principles underlying the International Rules. The application of the special articles dealing with fungi was treated in detail and the ambiguities leading to different interpretations pointed out.

Miss E. M. Wakefield followed with a detailed consideration of a number of proposed *Nomina Conservanda* indicating the points at issue and how that some of the names proposed were those which would be used if the International Rules were properly applied.

LIST OF MEMBERS

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38. British Museum, The Trustees of, Cromwell Road, South Kensington, London, S.W. 7. (1914.)
39. Brooks, Professor F. T., M.A., F.R.S., F.L.S., The Botany School, Cambridge. (1907.)

40. Brown University, Library, East Side Station, Providence, R.I., U.S.A. (1920.)
41. Brown, Professor W., M.A., D.Sc., Imperial College of Science, South Kensington, London, S.W. 7. (1922.)
42. Bruxelles, Jardin Botanique de l'État, c/o M. P. van Aerdschot. (1911.)
43. Buckley, Mr W. D., "Lynmouth", 2 Curzon Street, Slough. (1916.)
44. Buddin, Mr Walter, M.A., Laboratory of Plant Pathology, University of Reading, 7, Redlands Road, Reading. (1921.)
45. Buller, Professor A. H. R., D.Sc., Ph.D., F.R.S., University of Manitoba, Winnipeg, Canada. (1911.)
46. Bunting, Mr R. H., F.L.S., 3 Stanton Court, Weymouth. (1921).
47. Burges, Mr N. A., The Botany School, Cambridge. (1935.)
48. Burr, Mr S., M.Sc., Department of Agriculture, The University, Leeds. (1924.)
49. Butler, Mr E. J., C.I.E., C.M.G., D.Sc., M.B., F.R.S., F.L.S., Agricultural Research Council, 6 A, Dean's Yard, London, S.W. 1. (1920.)
50. Caldwell, Mr J., B.Sc., Ph.D., Department of Botany, University College, Exeter. (1932.)
51. Cambridge, The Botany School. (1920.)
52. Campbell, Mr A. H., B.Sc., Ph.D., Department of Botany, The University, Bristol. (1934.)
53. Carne, Mr W. M., F.L.S., Australia House, Strand, London, W.C. 2. (1928.)
54. Carr, Professor J. W., M.A., F.L.S., Mapperley Edge, Private Road, Sherwood, Nottingham. (1896.)
55. Carrothers, Mr. E. N., 7, Fitzwilliam Street, Belfast, N. Ireland, (1925.)
56. Carter, Miss F. M., Ph.D., Botanical Department, The University, Edgbaston, Birmingham, 15. (1934.)
57. Cartwright, Mr K. St G., M.A., F.L.S., The Red House, Kingston Blount, Oxford. (1913.)
58. Castellani, Sir Aldo, M.D., 23 Harley Street, London, W. 1. (1922.)
59. Cayley, Miss Dorothy M., John Innes Horticultural Institution, Mostyn Road, Merton Park, London, S.W. 19. (1913.)
60. Charles, Miss Vera K., United States Department of Agriculture, Bureau of Plant Industry, Washington D.C., U.S.A. (1933.)
61. Chaudhuri, Mr H., M.Sc., Ph.D., University of the Punjab, Lahore, India. (1920.)
62. Cheal, Mr W. F., Savile House, Queen's Road, Wisbech, Cambs. (1927.)

63. Chesters, Mr C. G. C., Botanical Department, The University, Edgbaston, Birmingham. (1930.)
64. Ciferri, Professor Dr R., Assistant Director, Laboratorio Critto-gamico, Casella Postale 165, Pavia, Italy. (1926.)
65. Clapham, Mr A. R., M.A., Ph.D., Department of Botany, The University, Oxford. (1931.)
66. Cleland, Mr J. Burton, M.D., Professor of Pathology, University of Adelaide, South Australia. (1918.)
67. Clouston, Mr D., M.A., B.Sc. (Agr.), North of Scotland College of Agriculture, Crown Mansions, 41, Union Street (2nd Floor), Aberdeen. (1931.)
68. Colston, Miss B., B.Sc., Ph.D., The University, Manchester. (1934.)
69. Connecticut Agricultural Experiment Station, New Haven, Connecticut, U.S.A. (1929).
70. Cook, Mr W. R. I., B.Sc., Ph.D., Department of Botany, University College, Newport Road, Cardiff. (1924.)
71. Cooke, Mr G. J., 143, Newmarket Road, Norwich. (1933.)
72. Cooper, Miss Charlotte A., California Lane, Bushey Heath, Herts. (1911.)
73. Cooper, Mrs V. Astley, The Tors, Knowle, Fareham, Hants. (1921.)
74. Cornell University, The Library, New York State College of Agriculture, Ithaca, N.Y., U.S.A. (1920.)
75. Corner, Mr E. J. H., M.A., F.L.S., Assistant Director, Botanic Gardens, Singapore, Straits Settlements. (1924.)
76. Cotton, Mr Arthur D., O.B.E., F.L.S., Keeper, Herbarium, Royal Botanic Gardens, Kew, Surrey. (1902.)
77. Cunningham, Mr G. H., Ph.D., Plant Research Station, Box 442, Palmerston North, New Zealand. (1922.)
78. Curtis, Miss Kathleen M., M.A., D.Sc., D.I.C., F.L.S., Mycologist, Biological Department, Cawthron Institute of Scientific Research, Nelson, New Zealand. (1917.)
79. Cutting, Mr E. M., M.A., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1920.)
80. Dade, Mr H. A., A.R.C.S., Imperial Mycological Institute, Ferry Lane, Kew, Surrey. (1927.)
81. Das, Mr Kedarnath, C.I.E., M.D., Principal, Carmichael Medical College, 1, Belgachia Road, Calcutta, India. (1922.)
82. Davies, Mr D. W., B.Sc., Adviser in Mycology, Agricultural Buildings, University College of Wales, Aberystwyth. (1923).
83. Davis, Mr J. Jefferson, B.S., M.D., University of Wisconsin, Madison, Wis., U.S.A. (1921.)
84. Day, Mr W. R., B.A., B.Sc., Imperial Forestry Institute, Oxford. (1928.)

85. Deacon, Dr G. E., Brundall, Norwich. (1933.)
86. Dehra Dun, The Forest Botanist, Forest Research Institute and College, U.P., India. (1929.)
87. Deighton, Mr F. C., M.A., Mycologist, Department of Lands and Forests, Freetown, Sierra Leone, West Africa. (1925.)
88. Dennis, Mr R. W. G., Ph.D., West of Scotland Agricultural College, 6, Blythswood Square, Glasgow. (1932.)
89. Dickinson, Mr S., School of Agriculture, Cambridge. (1921.)
90. Dobbs, Mr C. G., B.Sc., Botanical Department, King's College, Strand, London, W.C. 2. (1933.)
91. Dobinson, Mr H., 166, Piccadilly, London, W. 1. (1932.)
92. Dodge, Dr Carroll W., Missouri Botanical Garden, 2315, Tower Grove Avenue, St Louis, Missouri, U.S.A. (1926.)
93. Dowson, Mr W. J., M.A., D.Sc., The Botany School, Cambridge. (1920.)
94. Duncan, Mr J. T., London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C. 1. (1930.)
95. Edwards, Mr W. H., Belle Vue, Barline, Beer, Devon. (1896.)
96. Elliott, Mr W. T., D.D.S., L.D.S., F.L.S., F.Z.S., Arden Grange, Tanworth-in-Arden, Warwickshire. (1913.)
97. Elliott, Mrs J. S. Bayliss, D.Sc. (B'ham), B.Sc. (Lond.), Arden Grange, Tanworth-in-Arden, Warwickshire. (1911.)
98. Ellis, Mr E. H., B.Sc., Gramarye, Farley Green, Guildford, Surrey. (1936.)
99. Ellis, Miss E. M., St Hugh's College, Oxford. (1930.)
100. Ellis, Mr Holmes, F.R.M.S., 108, Birtwistle Avenue, Colne, Lancs. (1927.)
101. Emoto, Dr Y., Biological Department, Peers' College (Gakushuin), Mejiromachi, Tokyo, Japan. (1929.)
102. Essex Field Club, c/o Mr Percy Thompson, F.L.S., Essex Museum of Natural History, Romford Road, Stratford, London, E. 15. (1919.)
103. Exeter, Librarian, University College of the South-West of England. (1926.)
104. Eyre, Miss J. C., c/o Miss Wakefield, Herbarium, Royal Botanic Gardens, Kew. (1915.)
105. Fenton, Mr E. W., M.A., B.Sc., F.L.S., Biology Department, Edinburgh and East of Scotland College of Agriculture, Edinburgh. (1920.)
106. Findlay, Mr W. P., B.Sc., A.R.C.S., Courte Falaise, Sevenoaks, Kent. (1928.)
107. Finlayson, Mr Raymond A., F.L.S., Official Seed Testing Station, Huntingdon Road, Cambridge. (1910.)
108. Fisher, Mr S. D. P., Sackville Street, Leeds. (1930.)

109. Fitzpatrick, Professor H. M., Ph.D., 220, Bryant Avenue, Ithaca, New York, U.S.A. (1935.)
110. Forwood, Mr R., Minett, Muskoka, Ontario, Canada. (1930.)
111. Fountain, Mr A. S., F.R.M.S., 55, Moorgate, Rotherham, Yorks. (1934.)
112. Gadd, Mr C. H., D.Sc., Tea Research Institute, Nuwara Eliya, Ceylon. (1921.)
113. Galloway, Mr L. D., Imperial Institute of Agricultural Research, Delhi, India. (1928.)
114. Gardner, Capt. Frederic, c/o Barclays Bank, Jersey, C.I. (1898.)
115. Garside, Mr S., M.Sc., F.L.S., Botanical Department, Bedford College, Regent's Park, London, N.W. 1. (1922.)
116. Gates, Professor R. R., D.Sc., Ph.D., F.R.S., F.L.S., King's College, Strand, London, W.C. 2. (1921.)
117. Ghamrawy, Mr Ali K., 39 Monirah Street, Cairo, Egypt. (1932.)
118. Gibson, Miss C. J., B.A., 27, Banbury Road, Oxford. (1933.)
119. Gilbert, Dr E. M., Botanical Department, University of Wisconsin, Madison, Wis., U.S.A. (1922.)
120. Gilbert, M. E., Docteur en Pharmacie, 6, Rue de Laos, Paris (15ᵉ), France. (1924.)
121. Gisborne, Mr J. H., Keble College, Oxford. (1932.)
122. Glasstone, Mrs V. F. C., B.A. (Oxon.), 15, Northumberland Road, Sheffield. (1930.)
123. Glynne, Miss Mary D., M.Sc., F.L.S., Rothamsted Experimental Station, Harpenden, Herts. (1932.)
124. Gorman, Mr M. J., A.R.C.Sc.I., Albert Agricultural College, Glasnevin, Dublin. (1925.)
125. Gould, Mr F. G., Woodrising, Trapps Hill, Loughton, Essex. (1918.)
126. Green, Col. C. Theodore, A.M.S., M.R.C.S., L.R.C.P., F.L.S., 31, Shrewsbury Road, Birkenhead. (1901.)
127. Green, Miss E., M.Sc., 15, Gower Street, London, W.C. 1. (1925.)
128. Green, Miss F. Mary, M.A., Ph.D., 63, Canford Road, Clapham Common, London, S.W. 11. (1931.)
129. Gregor, Mrs M. J. F., Ph.D., Royal Botanic Garden, Edinburgh. (1927.)
130. Gregory, Mr P. H., Ph.D., Seale Hayne Agricultural College, Newton Abbot, Devon. (1930.)
131. Grieve, Mr B. J., M.Sc., Botanical Department, Melbourne University, Carlton, Victoria, Australia. (1931.)
132. Grinling, Mr C. H., B.A., 71, Rectory Place, Woolwich, London, S.E. 18. (1913.)

133. Grove, Miss Jessica H., 14, The Tything, Worcester. (1927.)
134. Gwynne-Vaughan, Professor Dame Helen, G.B.E., D.Sc., LL.D., F.L.S., 93, Bedford Court Mansions, London, W.C. 1. (1906.)
135. Hanna, Mr W. F., M.Sc., Dominion Rust Research Laboratory, Agricultural College, Winnipeg, Canada. (1925.)
136. Hansford, Mr C. G., M.A., F.L.S., Mycologist, Department of Agriculture, Kampala, Uganda. (1921.)
137. Harley, Mr J. L., Shrublands, Hethersett, Norfolk. (1932.)
138. Harris, Mr G. C. M., 148, Divinity Road, Oxford. (1934.)
139. Harris, Mr R. V., B.Sc., A.R.C.S. Horticultural Research Station, East Malling, Kent. (1924.)
140. Harrison, Mr T. H., D.Sc. Hawkesbury Agricultural College, Richmond, N.S. Wales, Australia. (1931.)
141. Harvard University, The Library, Cambridge, Mass., U.S.A. (1923.)
142. Hastings, Mr Somerville, M.S., F.R.C.S., 43, Devonshire Street, Portland Place, London, W. 1. (1913.)
143. Hawker, Miss L. E., Botanical Department, Imperial College of Science, London, S.W. 7. (1934.)
144. Heim, M. Roger, Sous-Directeur au Muséum d'Histoire Naturelle, 11, Rue de Médicis, Paris (6e), France. (1930).
145. Heimbeck, Mrs Louise, Brosoe, Levanger, Norway. (1923.)
146. Hemmi, Dr Takewo, Phytopathological Institute, Department of Agriculture, Kyoto Imperial University, Kyoto, Japan. (1923.)
147. Hereford, Mr E. H., 131, Queen Victoria Street, London, E.C. 4. (1933.)
148. Hickman, Mr C. J., Research Station, Long Ashton, nr. Bristol. (1935.)
149. Hildyard, Mr F. W., 1, Lichfield Road, Kew, Surrey. (1913.)
150. Holden, Professor H. S., D.Sc., F.L.S., Botanical Department, University College, Nottingham. (1923.)
151. Honolulu, Association of Hawaiian Pineapple Canners, P.O. Box 3166, Hawaii. (1929.)
152. Honolulu, The Library, Experimental Station, S.P.A., Box 411, Hawaii. (1920.)
153. Hopkins, Mr J. C. F., D.Sc., A.I.C.T.A., P.B. 74 B, Salisbury, S. Rhodesia. (1930.)
154. Horne, Mr A. S., D.Sc., F.L.S., F.G.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1921.)
155. Howard, Mr H. J., F.R.M.S., F.L.S., "Lingfield", 6, College Road, Norwich. (1918.)

156. Hubbard, Miss M. D., B.Sc., Department of Botany, University College of Wales, Aberystwyth. (1933.)
157. Hughes, Mr G. C., Priory Road, Bicester. (1898.)
158. Hughes, Mr J. S., M.A., University Observatory, Oxford. (1927.)
159. Hull, The Librarian, Botanical Department, University College. (1929.)
160. Humphrey, Dr C. J., United States Department of Agriculture, Soil Conservation Service, Safford, Arizona, U.S.A. (1921.)
161. Hurrell, Mr H. E., 60, Albany Road, Great Yarmouth. (1921.)
162. Hurst, Mr C. P., Landulph Rectory, Saltash, Cornwall. (1928.)
163. Ingold, Mr C. T., M.Sc., Ph.D., Department of Botany, The University, Reading. (1935.)
164. Iowa, The Library, State University of Iowa, Library Annex, Iowa City, U.S.A. (1923.)
165. Iowa State College, Library, Ames, Iowa, U.S.A. (1927.)
166. Issatchenko, Professor B. L., Directeur du Jardin Botanique, Leningrad, Russia. (1923.)
167. John Crerar Library, 86, East Randolph Street, Chicago, Illinois, U.S.A. (1929.)
168. John Innes Horticultural Institution, Mostyn Road, Merton Park, London, S.W. 19. (1924.)
169. Johnson, Mr J. W. Haigh, M.Sc., F.I.C., F.L.S., Walton, nr Wakefield. (1919.)
170. Jones, Mr G. H., M.A., Plant Protection Section, Ministry of Agriculture, Cairo, Egypt. (1922.)
171. Jørstad, Mr Ivar, Statsmykolog, Botanisk Museum, Oslo, Norway. (1923.)
172. Keay, Miss M. A., M.A. (Cape Town), The Botany School, Cambridge. (1935.)
173. Keissler, Dr Karl, Direktor d. Botanischen Abteilung, Naturhistorisches Museum, Burgring 7, Wien 1/1, Austria. (1924.)
174. Kelly, Dr Howard A., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921.)
175. King, Miss M. E., B.A., The Botany School, Cambridge. (1935.)
176. Klika, Mr Bohumil, Hálkova 37, Prague, Vrsovice 553, Czechoslovakia. (1926.)
177. Knight, Mr H. H., M.A., The Lodge, All Saints' Villas, Cheltenham. (1914.)
178. Kuala Lumpur, F.M.S., The Director of Agriculture, Straits Settlements, and Federated Malay States. (1930.)
179. Lamb, Mr I. M., B.Sc., 18, Duke's Avenue, Kingston-on-Thames, Surrey. (1934.)

180. Lampitt, Mr L. H., D.Sc., F.I.C., Thornlea, Mount Park, Harrow, Middlesex. (1925.)
181. Leach, Mr R., B.A., Agricultural Department, Mlanje, Nyasaland. (1929.)
182. Leicester, The Museum, City of Leicester. (1923.)
183. Linder, Dr D., Farlow Herbarium, Harvard University, 20, Divinity Avenue, Cambridge, Mass., U.S.A. (1935.)
184. Line, Mr James, M.A., School of Agriculture, Cambridge. (1921.)
185. Linnean Society, The, Burlington House, Piccadilly, London, W. 1. (1919.)
186. Lloyd Library, The, 309, West Court Street, Cincinnati, Ohio, U.S.A. (1907.)
187. Loader, Miss F. M., B.Sc., Botanical Department, University College, Southampton. (1927.)
188. Lowndes, Mr A. G., M.A., F.L.S., Marlborough College, Marlborough, Wilts. (1922.)
189. Lütjeharms, Mr W. J., Assistent aan's Rijks Herbarium, Leiden, Holland. (1930.)
190. McDonald, Mr J., D.F.C., B.Sc., F.L.S., Senior Plant Pathologist, P.O. Box 338, Nairobi, Kenya Colony, East Africa. (1923.)
191. McLennan, Dr Ethel I., Botanical Department, Melbourne University, Carlton, Victoria, Australia. (1926.)
192. Madras University Library, Senate House, Triplicane, Madras, South India. (1925.)
193. Maire, M. René, D.Sc., F.M.L.S., Professeur à la Faculté des Sciences de l'Université, Algiers, Algeria, N. Africa. (1907.)
194. Marsh, Mr R. W., M.A., Research Station, Long Ashton, Bristol. (1923.)
195. Masefield, Mr G. B., c/o Department of Agriculture, Entebbe, Uganda. (1932.)
196. Mason, Mr E. W., M.A., M.Sc., F.L.S., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1921.)
197. Mason, Mrs E. W., Inglenook, 63, King's Road, Richmond, Surrey. (1922.)
198. Mason, Mr F. A., F.R.M.S., M.S.P.A., 29, Frankland Terrace, Leeds. (1912.)
199. Matthews, Professor J. R., M.A., F.L.S., Department of Botany, The University, Old Aberdeen. (1921.)
200. Mehta, Professor K. C., Ph.D., Department of Biology, Agra College, Agra, U.P., India. (1921.)
201. Melville, Mr R., B.Sc., Ph.D., 5, Courtway, Twickenham, Middlesex. (1933.)

202. Metcalfe, Mr C. R., B.A., Ph.D., Jodrell Laboratory, Royal Botanic Gardens, Kew, Surrey. (1926.)
203. Michigan Agricultural College Library, East Lansing, Michigan, U.S.A. (1924.)
204. Miller, Professor J. H., B.S., M.S., Ph.D., University of Georgia, Athens, Ga., U.S.A. (1930.)
205. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902.)
206. Mitra, Mr M., M.Sc., Ph.D., D.I.C., Assistant Mycologist, Imperial Institute of Agricultural Research, Delhi, India. (1928.)
207. Miyabe, Dr Kingo, Professor Emeritus of Botany, Hokkaido Imperial University, Sapporo, Japan. (1919.)
208. Montague, Mrs A., Penton, Crediton, N. Devon. (1898.)
209. Montreal, Canada, Faculté des Sciences, Institut Botanique, Université de Montréal. (1932.)
210. Moore, Mr W. C., M.A., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1922.)
211. Morgan, Dr G., Ashley-Hatton, Dyke Road Avenue, Brighton. (1928.)
212. Morris, Mr L. E., c/o Eton College, Windsor, Berks. (1924.)
213. Muller, Dr H. R. A., Institut voor Plantenziekten, Buitenzorg, Java. (1932.)
214. Murphy, Professor P. A., Sc.D., A.R.C.Sc.I., M.R.I.A., Department of Plant Pathology, Albert Agricultural College, Glasnevin, Dublin, N.W. 3. (1924.)
215. Murray, Mr G. H., F.E.S., Director of Agriculture, Rabaul, New Britain, Territory of New Guinea, *via* Australia. (1921.)
216. Muskett, Mr A. E., M.Sc., A.R.C.S., Queen's University, Belfast, Northern Ireland. (1923.)
217. Nannfeldt, Dr J. A., Sturegatan 11, Uppsala, Sweden. (1932.)
218. National Collection of Type Cultures, Curator, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
219. National Museum of Wales, Cardiff. (1924.)
220. Nattrass, Mr R. M., B.Sc. (Agric.), Ph.D., Department of Agriculture, Nicosia, Cyprus. (1925.)
221. Nebraska, The Library, University of, Lincoln, Nebr., U.S.A. (1924.)
222. Nederlandsche Mycologische Vereeniging, c/o Mr A. C. S. Schweers, Nassaulaan 17, Alkmaar, Holland. (1920.)
223. Nelson, Miss M. G., M.A., Botanical Department, The University, Oxford. (1932.)
224. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904.)
225. Nicholson, Mr W. E., F.L.S., 50, St Anne's Crescent, Lewes. (1913.)

226. Noel, Miss E. F., F.L.S., 37, Burnham Court, Queen's Road, London, W. 2. (1913.)
227. North Carolina, Library, University of, Chapel Hill, North Carolina, U.S.A. (1920.)
228. Nursery and Market Garden Industries' Development Society, Ltd., Experimental and Research Station, Cheshunt, Herts. (1922.)
229. O'Connor, Mr P., Ph.D., B.Sc., A.R.C.Sc.I., National Museum, Dublin. (1925.)
230. Ogilvie, Mr L., M.A., M.Sc., Research Station, Long Ashton, nr Bristol. (1922.)
231. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove, Sussex. (1908.)
232. Ontario Agricultural College, Library, Guelph, Ontario, Canada. (1920.)
233. Oort, Dr A. J. P., Ericalaan 5, Wageningen, Holland. (1935.)
234. Osborn, Professor T. G. B., D.Sc., F.L.S., Botanical Department, The University, Sydney, N.S.W., Australia. (1910.)
235. Ottawa, Ontario, Canada, The Library, Geological Survey. (1926.)
236. Padwick, Dr G. Watts, Jealott's Hill Agricultural Research Station, Bracknell, Berks. (1936.)
237. Page, Miss W. M., M.Sc., 19, Ledam Buildings, Bourne Estate, Holborn, London, E.C. 1. (1921.)
238. Park, Mr M., Department of Agriculture, Peradeniya, Ceylon. (1929.)
239. Parke Davis & Co., Medical Research Library, P.O. Box 488, Detroit, Michigan, U.S.A. (1920.)
240. Parker, Professor C. S., Department of Botany, Howard University, Washington, D.C., U.S.A. (1932.)
241. Pearson, Mr Arthur A., F.L.S., 59, Southwark Street, London, S.E. 1. (1911.)
242. Peklo, Dr Jaroslav, Professor of Applied Botany, Bohemian Technical University, Charles Square, Prague II, Czechoslovakia. (1924.)
243. Perthshire Society of Natural Science, c/o Mr James Winter (Hon. Treasurer), 35, George Street, Perth. (1919.)
244. Petch, Mr T., B.A., B.Sc., North Wootton, King's Lynn, Norfolk. (1911.)
245. Pethybridge, Mr G. H., Ph.D., B.Sc., F.L.S., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919.)
246. Peyronel, Dr Benjamino, R. Istituto Sup. Agrario e Forestale, Piazzale del Re, Firenze, Italy. (1932.)

247. Philadelphia, The Academy of Natural Sciences of Philadelphia, Nineteenth and The Parkway, Phil., U.S.A. (1925.)
248. Phillips, Dr H. H., 6, St John's Road, Penge, London, S.E. 10. (1923.)
249. Ping, Mr A. Wentworth, M.A., "St Olave's", Clifton, York. (1926.)
250. Potter, Rev. M. C., Sc.D., M.A., F.L.S., Corley Croft, New Milton, Hants. (1896.)
251. Preston, Mr N. C., B.Sc., Harper Adams Agricultural College, Newport, Salop. (1920.)
252. Pretoria, South Africa, The Chief, Division of Plant Industry (91403), Department of Agriculture. (1922.)
253. Purdue University, Library, Agricultural Experiment Station, Lafayette, Ind., U.S.A. (1931.)
254. Pusa, Imperial Mycologist, Imperial Agricultural Research Institute, Delhi, India. (1921.)
255. Ramsbottom, Mr J., O.B.E., M.A., F.L.S., British Museum (Nat. Hist.), Cromwell Road, South Kensington, London, S.W. 7. (1910.)
256. Ray, Miss Anne, Penarwyn, Gorran Haven, Gorran, Cornwall. (1929.)
257. Rayner, Dr M. Cheveley (Mrs Neilson Jones), Bedford College for Women, Regent's Park, London, N.W. 1. (1921.)
258. Rea, Miss M. W., M.Sc., Salem House, Sydenham, Belfast, Northern Ireland. (1920.)
259. Rees, Mr John, M.Sc., Adviser in Agricultural Botany, University College, Cardiff. (1929.)
260. Reichert, Dr Israel, Jewish Agency for Palestine, Agricultural Experiment Station, P.O.B. 15, Rehoboth, Palestine. (1924.)
261. Rhind, Mr Donald, B.Sc., Economic Botanist, Department of Agriculture, Agricultural College, Mandalay, Burma. (1922.)
262. Rhodes, Miss Mabel, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
263. Robson, Mr R., M.Sc., F.Z.S., East Hanningfield, Chelmsford, Essex. (1914.)
264. Rothamsted Experimental Station, Department of Mycology, Harpenden, Herts. (1923.)
265. Rutgers College and State University of New Jersey, Library, New Brunswick, New Jersey, U.S.A. (1922.)
266. St Paul, Minnesota, U.S.A., The Library, Department of Agriculture, University Farm. (1920.)
267. Salisbury, Professor E. J., D.Sc., F.R.S., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1921).

268. Salmon, Professor E. S., F.L.S., South-Eastern Agricultural College, Wye, Kent. (1922.)
269. Sampson, Miss K., M.Sc., University College, Aberystwyth, North Wales. (1920.)
270. Samuel, Mr Geoffrey, M.Sc., Department of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1923.)
271. Scott, Mr W. W., 13, Bishop's Road, Highgate, London, N. 6. (1922.)
272. Searle, Mr G. Odell, B.Sc. (Agric.), Flax Research Institute, Flitcham Abbey, nr. King's Lynn, Norfolk. (1920.)
273. Seth, Mr N. L., B.Sc., Ph.D., D.I.C., Agricultural College, Mandalay, Burma. (1930.)
274. Sharples, Mr A., A.R.C.S., D.I.C., c/o Messrs Grindlay & Co., Parliament Street, London, S.W. 1. (1924.)
275. Shaw, Mr F. J. F., D.Sc., A.R.C.S., F.L.S., Imperial Agricultural Research Institute, Delhi, India. (1920.)
276. Shear, Dr C. L., U.S. Department of Agriculture, Bureau of Plant Industry, Washington, D.C., U.S.A. (1930.)
277. Small, Mr W., M.B.E., M.A., Ph.D., B.Sc., Director, Department of Agriculture, Zomba, Nyasaland. (1915.)
278. Smith, Mr Alexander, M.A., Ph.D., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1924.)
279. Smith, Miss K. E., The Quarry, Lutterworth Road, Nuneaton. (1913.)
280. Smith, Professor Noel J. G., Ph.D., B.Sc., Botany Department, Rhodes University College, Grahamstown, S. Africa. (1924.)
281. Smith, Mr Rupert, 38, Greenhill Gardens, Edinburgh. (1927.)
282. South London Botanical Institute, 323, Norwood Road, Tulse Hill, London, S.E. 24. (1921.)
283. Stakman, Professor E. C., University of Minnesota, Department of Agriculture, University Farm, St Paul, Minn., U.S.A. (1922.)
284. Statham, Miss E. M., 2, Westbrook Road, Blackheath, London, S.E. 3. (1926.)
285. Stationery Office, H.M., Superintendent of Publications, Book Dept., Westminster, S.W. 1. (4 subscriptions.) (1920.)
286. Stephens, Miss E. L., B.A., Department of Botany, University of Cape Town, Cape Town, South Africa. (1928.)
287. Stephens, Miss F. L., M.Sc., Department of Botany, British Museum (Natural History), Cromwell Road, South Kensington, London, S.W. 7. (1930.)

288. Steyaert, M. R. L., Station de Sélection Cotonnière de Bambesa, District des Uélés, Belgian Congo. (1931.)
289. Stirrup, Mr H. H., M.Sc., Midland Agricultural College, Sutton Bonington, Loughborough. (1922.)
290. Storey, Mr H. H., M.A., Ph.D., East African Agricultural Research Institute, Amani, Tanganyika Territory, East Africa. (1922.)
291. Sutherland, Mr G. K., M.A., D.Sc., F.L.S., "Bremhill", 21, Combe Park, Bath, Somerset. (1914.)
292. Swanton, Mr E. W., M.B.E., A.L.S., Educational Museum, Haslemere, Surrey. (1899.)
293. Swedish Academy of Sciences, Royal, Stockholm, Sweden. (1919.)
294. Sydney, Australia, The Librarian, University of. (1922.)
295. Sydow, Herr H., Luitpoldstrasse 33, Berlin, W. 30, Germany. (1931.)
296. Tabor, Mr R. J., B.Sc., F.L.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1914.)
297. Telfer, Mr R. Allsop, St Cuthbert's, Malvern. (1931.)
298. Tennessee, University of, Agricultural Experiment Station, Library, Knoxville, Tennessee, U.S.A. (1926.)
299. Tervet, Mr I. W., B.Sc., Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh. (1933.)
300. Tetley, Miss U., Quarry Garth, Windermere, Westmorland. (1929.)
301. Tomkins, Mr R. G., M.A., Ph.D., Trinity College, Cambridge. (1925.)
302. Topping, Mrs M. P., 3, Southdown Crescent, Cheadle Hulme, Cheshire. (1930.)
303. Tunstall, Mr A. C., Tocklai Experimental Station, Cinnamara P.O., Assam, British India. (1933.)
304. Vaheeduddin Syed, Department of Plant Pathology, University Farm, St Paul, Minnesota, U.S.A. (1934.)
305. Vanterpool, Mr T. C., M.Sc., Botanical Department, University of Saskatchewan, Saskatoon, Canada. (1929.)
306. Vasudeva, Mr R. S., Cotton Pathologist, Agricultural College, Lyallpur, Punjab, India. (1929.)
307. Venkatarayan, Mr S. V., Senior Assistant Mycologist, Agricultural Department, Bangalore, S. India. (1935.)
308. Wadham, Professor S. M., M.A., Department of Agriculture, The University, Melbourne, Victoria, Australia. (1922.)
309. Wakefield, Miss E. M., M.A., F.L.S., Herbarium, Royal Botanic Gardens, Kew. (1911.)

310. Waldie, Mr J. S. L., B.Sc., C.D.A., Department of Agricultural Botany, The University, Reading. (1925.)
311. Wales, University College of, Librarian, Botanical Department, Aberystwyth, North Wales. (1927.)
312. Wallace, Mr E. R., Agricultural Institute, Kirton, nr Boston, Lincs. (1934.)
313. Wallace, Mr G. B., B.Sc. (Agric.), Ph.D., Department of Agriculture, Morogoro, Tanganyika Territory, East Africa. (1928.)
314. Wallace, Mrs G. B., B.Sc., Morogoro, Tanganyika Territory, East Africa. (1924.)
315. Wallis, Mr A., Westacre, Station Road, Kettering. (1921.)
316. Ware, Mr W. M., D.Sc., South-Eastern Agricultural College, Wye, Kent. (1924.)
317. Washington, Library, State College of, Pullman, Washington, U.S.A. (1924.)
318. Waterston, Mr J. M., B.Sc., 113, Marchmont Road, Edinburgh. (1934.)
319. Watson, Mr W., D.Sc., A.L.S., Cedene, Cheddon Road, Taunton. (1933.)
320. Westerdijk, Professor Johanna, Javalaan 4, Baarn, Holland. (1923.)
321. Western, Mr J. H., B.Sc., Department of Agricultural Botany, University College of Wales, Aberystwyth. (1934.)
322. Weston, Mr W. A. R. Dillon, M.A., School of Agriculture, Cambridge. (1923.)
323. Whetzel, Professor H. H., M.A., New York State College of Agriculture, Cornell University, Ithaca, N.Y., U.S.A. (1914.)
324. Whitaker, Mr F. Owen, 51, Grosvenor Avenue, Carshalton, Surrey. (1921.)
325. Whitehead, Mr T., D.Sc., A.R.C.S., University College of North Wales, Bangor. (1920.)
326. Wilkins, Mr W. H., M.A., D.Ph. Department of Botany, The University, Oxford. (1928.)
327. Williams, Mr P. H., 4, Belmont Villas, Windmill Lane, Cheshunt, Herts. (1930.)
328. Wilson, Miss A. P., M.B.E., A.R.C.S., 116, Fellows Road, London, N.W. 3. (1929.)
329. Wilson, Mr Alastair R., B.Sc., The Botany School, Cambridge. (1933.)
330. Wilson, Mr Malcolm, D.Sc., A.R.C.S., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
331. Wiltshire, Mr S. P., M.A., Imperial Mycological Institute, Ferry Lane, Kew, Surrey. (1920.)

332. Wisconsin, The Library, University of, Madison, Wis., U.S.A. (1923.)
333. Wolf, Mr B. L., N.D.A., Cornwall Buildings, 45, Newhall Street, Birmingham. (1923.)
334. Wood, Mr F. C., 20, South Farm Road, Worthing, Sussex. (1935.)
335. Woodcock, Mr A. J. A., M.Sc., F.E.S., Rhianva, 65, Rock Avenue, Gillingham, Kent. (1926.)
336. Woodward, Mr R. C., Ph.D., Imperial Chemical Industries, Ltd., Millbank, London, S.W. 1. (1924.)
337. Woolhope, The Naturalists' Field Club, Hereford. (1896.)
338. Worcestershire Naturalists' Field Club, c/o Mr W. J. Else, Victoria Institute, Worcester. (1921.)
339. Wormald, Mr H., D.Sc., A.R.C.S., Research Station, East Malling, Kent. (1921.)
340. Yale University, Library, New Haven, Connecticut, U.S.A. (1930.)
341. Yeoman, Mr J. B., M.D., Norton, Wirral, Cheshire.
342. Young, Miss Elaine M., Ph.D., M.Sc., c/o The Forest Department, Knysna, Cape Province, South Africa. (1927.)
343. Zundel, Dr G. L. I., Botany Building, Pennsylvania State College, State College, Pa., U.S.A. (1929.)
344. Zürich, Switzerland, Botanical Garden and Museum, c/o Dr A. U. Däniker. (1921.)
345. Zürich, Institut für Spezielle Botanik der Eidg. Techn. Hochschule. (1928.)

RULES

Society's Name and Objects

1. The Society shall be called "The British Mycological Society", and its object shall be the study of Mycology in all its branches.

Members of Society

2. The Society shall consist of Honorary Members, Foundation Members, and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100, but the number of Ordinary Members shall be unlimited.

Honorary Members

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained.*

Officers

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries and Editor or Editors. They shall be elected annually, at the Annual General Meeting of the Society.

Government of Society

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex-officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

Period of Office

7. The Officers and Council shall hold office as from the 1st of January following their election.

* The limit of 100 Foundation Members was reached 22nd October, 1903.

Plant Pathology Committee

8. The special interests of Plant Pathology shall be delegated to an executive committee, to be called the Plant Pathology Committee of the British Mycological Society. This Committee shall consist of the President and Secretaries *ex-officio* and twelve other members of the Society. The latter shall be elected annually at the Annual General Meeting of the Society, and one-quarter shall retire in rotation each year and shall not be eligible for immediate re-election. The members to retire shall be those who have been longest in office, or, in case of equality, shall be determined by ballot.

The Officers shall consist of a Chairman and a Secretary, to be elected by the Committee each year.

At least two meetings shall be held every year, six members to form a quorum.

The Committee shall have power to appoint for any special purpose a sub-committee consisting either wholly or partly of members of the Committee.

Election of Members

9. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see Appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see Appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription

10. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

Meetings

11. The Society shall hold one or more meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting, for the election of officers and the transaction of other business, shall coincide with the Autumn Foray.

Accounts

12. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules

13. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alterations to all Members.

APPENDIX

Form of proposal for Ordinary Membership of the British Mycological Society

....

of ....

....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h   to be a desirable Member of the Society, and beg to recommend h   for election.

Dated this   day of   19

....(From personal knowledge.)

Certificate to be signed by the Candidate

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

....

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New names are indicated by an asterisk.